U.S. Department of Transportation

USDOT
CLIMATE STRATEGIES THAT WORK

Prepared By :
USDOT Climate Change Center

January 2025

The USDOT Climate Strategies that Work Playbook is a comprehensive resource to guide cities, regions, industry leaders, philanthropic strategists, and transportation professionals at every level in implementing the most effective strategies for reducing transportation sector greenhouse gas emissions. This playbook provides strategies to help communities grow stronger, safer, smarter, and more sustainable. Informed by the U.S. National Blueprint for Transportation Decarbonization, the playbook emphasizes convenient, efficient, and clean transportation solutions, while also considering equity, safety, and economic growth.

The playbook provides actionable information for 27 transportation-related emission reduction strategies through well-vetted guides detailing benefits, implementation steps, and resources.

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14. ABSTRACT

This report presents research-based climate action strategies for State, Tribal, city, and local governments. The "Climate Strategies That Work" playbook includes 27 climate solutions that can help communities reduce carbon pollution and create a more resilient, sustainable, and accessible transportation system for all Americans. The playbook emphasizes efficient, convenient, and clean transportation solutions that support safe and economically vibrant communities across the United States. Strategies span infrastructure investments, technology applications, and policy strategies. These include active transportation, pricing programs, electric vehicles, and freight operational efficiencies for use by rural and urban communities. The strategies are informed by the U.S. National Blueprint for Transportation Decarbonization and include information on achieving greenhouse gas reductions, economic development, and safety benefits, along with funding opportunities and case studies that illustrate the impacts of these strategies in action.

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U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

ACTIVE TRANSPORTATION

Safe, comfortable, and continuous active transportation networks seamlessly connect people to places, foster healthier communities, and reduce reliance on carbon-intensive modes of travel.

Also known as

NONMOTORIZED TRAVEL, BIKE/PEDESTRIAN, OR MICROMOBILITY

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural, & Tribal

Walking, biking, and rolling—collectively known as active transportation or micromobility—are fundamental elements of **sustainable, connected, and vibrant communities**. Nearly every trip involves active transportation, from walking to a bus stop to cycling the final stretch to work. This inherent connection to daily travel is underscored by recent data from Bureau of Transportation Statistics: in 2021, **over half (52%) of all trips in the U.S. were less than three miles** – suitable for a twenty-minute bike ride; and a **significant portion (28%) of trips were less than one mile**.

Given that most people are comfortable walking up to half a mile and cycling up to two and a half miles for everyday trips, the potential for active transportation to reduce greenhouse gas emissions becomes readily apparent. Investments in well-designed, inclusive active transportation infrastructure and programs offer benefits that extend beyond the environmental gains. These networks create a more **engaging, affordable, accessible, and convenient travel experience**, while helping to ensure people are connected to the outdoors and essential daily destinations like work, school, healthcare, and community centers.

Did you know?

U.S. Department of Transportation (DOT)'s Strategic Plan for 2022-2026 sets a target to increase the percentage of trips by transit and active transportation modes by 50%.

Electric micromobility options, like e-bikes and e-scooters, expand the reach of active transportation, making slightly longer distances feasible for more users, and further reducing car dependence. These networks create a more engaging, affordable, healthy, and convenient travel experience. Additionally, active transportation serves as a valuable extension of public transit, bridging the first- and last-mile gaps for riders.

Active transportation networks can also contribute to more sustainable and efficient urban freight delivery by enabling cargo bikes and other

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micromobility devices to navigate urban areas with greater ease, reducing the reliance on delivery trucks. With more people walking and cycling, streets become more vibrant and inviting, cultivating a sense of community and increasing foot traffic for local businesses.

A safe and accessible active transportation network goes beyond just physical infrastructure. ***Elements of bicycle and pedestrian infrastructure and supportive programs may include:***

Infrastructure for Bike/Scooters/Other Micromobility Devices

- Protected or shared bike lanes
- Separation/buffers
- Intersection treatments for bicycles (bicycle boxes, stop bars, lead signal indicators)
- Wayfinding and Signage
- Secure parking and storage facilities
- Bike and Scooter Share Programs *(Read more at the Shared Micromobility & Microtransit Page)*
- Bike Repair/Tool Stations
- Bike Rebates and Tax Credits
- Bike Schools, Bike Ambassadors and Capacity Building
- Community Rides
- Ramps
- Bike Racks

Shared Infrastructure

- Lighting
- Workplace or destination-based facilities / supportive infrastructure (lockers, changing facilities, secure parking)
- Traffic calming
- Integration with Transit

Infrastructure for Pedestrians

- Curb extensions (also known as Bulb-outs)
- Landscaping, Street Furniture, and Shade
- Quality, continuous, wide sidewalks
- Tactile wayfinding systems to assist visually impaired travelers
- Signalized, high visibility pedestrian crossings with Audible and Visual Countdowns
- Mid-block/refugee islands
- Bicycle/pedestrian bridges
- Pedestrian Zones/Pedestrian Streets
- Woonerf or "Living Street" *(Characterized by shared spaces where vehicles are allowed but must yield to non-motorized users, woonerfs encourage slower speeds and foster community interaction)*

Supporting Public Policy

- Land-use regulation to encourage pedestrian-oriented infrastructure
- Micromobility parking and charging standards

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

CYCLING AND OTHER FORMS OF ACTIVE TRANSPORTATION ARE LESS EMISSION-INTENSIVE THAN OTHER OPTIONS

Passenger vehicles produce approximately 0.95 lbs. of CO_2 per passenger-mile compared to 0.05 lbs. of CO_2 per passenger-mile emitted by biking (European Cycling Federation, 2016).

This study considered not just the emissions from the vehicles themselves, but from the entire fuel and vehicle lifecycle including production, maintenance, and fuel.

BENEFITS FROM A COMPREHENSIVE APPROACH

Each mile driven produces approximately 1 pound of CO_2 emissions, assuming an average vehicle fuel economy of 25 miles per gallon. If modest improvements are made to promote more walking and bicycling across the U.S. for trips up to 3 miles, over 1,000 million gallons in fuel or 9 million tons of CO_2 emissions could be avoided (Rails to Trails, 2019).

If the length of trips in the U.S. are reduced by only 1-3% through denser, mixed use developments, an additional 500 million gallons in fuel could be saved, or over 4 million tons of CO_2 emissions (Rails to Trails, 2019).

BENEFITS FROM SPECIFIC STRATEGIES

Provide Pedestrian Network Improvements: A study by the California Air Pollution Control Officers Association (CAPCOA) estimates that increasing sidewalk coverage to improve pedestrian access can reduce GHG emissions from vehicle travel by 6.4% (CAPCOA, 2021).

Bikeshare Program: A study quantifying the environmental benefits of bike share trips across different metropolitan bike share systems estimated the annual reduction in 2016 in Seattle to be 41 tons of CO_2e, and as large as 5,417 tons of CO_2e in New York City (Kou et al., 2020).

Roadway Reconfigurations: By reconfiguring streets, cities and towns can allocate more space for pedestrians and cyclists and contribute to GHG reductions. A reconfiguration project in Davis, California resulted in an estimated reduction of 24.4 metric tons of CO_2e over a 12-year period. The 0.8-mile segment was reduced from four vehicle lanes to two vehicle lanes, with a bike lane on other side, and an isolation strip in between (California Climate Investments Quantification Methods Assessment, 2019).

CHOOSING ACTIVE TRANSPORT REDUCES GHG EMISSIONS AND VEHICLE MILES TRAVELED

Even seemingly small changes can have a significant impact on GHG emissions. Studies show that if residents in a city of 50,000 people switched just one mile of their daily trips from driving to active transportation, this choice could result in a collective reduction of 10.14 million pounds (5,070 tons) of CO_2 per year and nearly 400,000 fewer miles driven (HUD, 2016).

An RMI analysis explored the VMT reduction potential of cutting vehicle trips under 5 miles. Across 10 large cities, shifting 25 percent of short vehicle trips from cars to e-bikes would cut overall VMT by an average of 3% and annual CO_2-equivalent emissions by over 1.8 million metric tons or 4.2 million barrels of oil. Shifting a more modest 1 out of every 8 trips to an e-bike would cut 920,000 metric tons of CO_2e emissions (Grunwald, et al., 2023).

> The average American drives about 1,200 miles monthly. Reducing these vehicle trips in the 10 largest cities equates to removing over 388,000 vehicles from the road (Grunwald, et al., 2023).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Investments in and the expansion of active transportation infrastructure are **proven safety countermeasures** promoted by FHWA for reducing roadway fatalities and serious injuries.

> See other FHWA Safety Countermeasures here.

Researchers are finding that cities with a high level of bicycling are not just safer for cyclists but for all road users. U.S. cities with higher per capita bicycling rates tend to have lower traffic fatality rates for all road users, which can be partly attributed to increased street network density that supports cycling and lower traffic speeds (Marshall and Garrick, 2011). Investing in active transportation not only improves actual safety but also enhances the **perception of safety**. A higher volume of people walking and cycling fosters a stronger sense of community (University of Colorado Denver, 2014).

Communities designed with pedestrians, bicyclists, and other micromobility users in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways. Safer streets and connecting trails can, in turn, encourage further shifts towards active transportation (Bas et al., 2023).

> An example of the federal government's commitment to increase the safety of infrastructure can be found here: DOT Fiscal Year 2022-2026 Strategic Plan

ACCESSIBILITY AND EQUITY

By reducing reliance on cars, prioritizing safety, and fostering connections, active transportation creates a more equitable and accessible transportation system that benefits all members of the community. This is achieved through inclusive infrastructure planning and design that caters to a variety of abilities and experiences (FHWA, 2023).

One study estimated that 20-40% of the population in most communities cannot or should not drive due to disability, low incomes, or age. Active transportation improvements benefit existing users as well as new users who walk and bike more following improvements.

Increasing the safety and accessibility of active transportation can allow non-drivers to live more independently and provide greater access to economic opportunities (Litman, 2024b).

ECONOMIC GROWTH

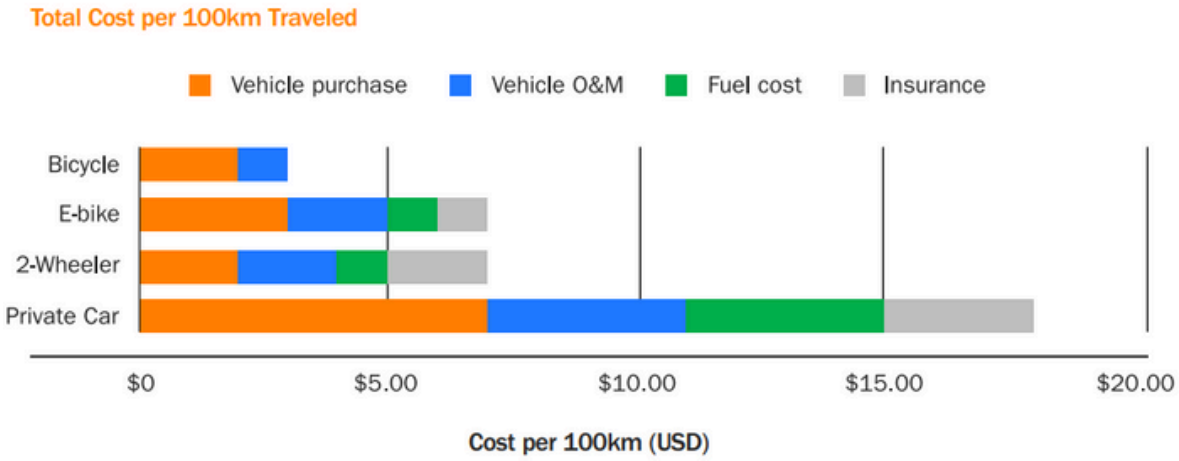
Communities with well-connected active transportation networks experience increased foot traffic, which translates to economic benefits for local businesses (Smart Growth America, 2015).

Investing in active transportation infrastructure creates jobs. International Energy Agency (IEA) data suggests that pedestrian and bike lanes generate 8 to 22 jobs for every million dollars spent. These jobs typically involve construction, painting, signage installation, and paving (IEA, 2020).

This job growth is comparable to investments in charging infrastructure which can generate 7 to 21 jobs per million dollars spent; higher than railway investments, battery electric car manufacturing which produce 5 to 9 jobs, and 4 to 8 jobs per million dollars spent, respectively (IEA, 2020).

COST SAVINGS

Owning and operating a bicycle is considerably cheaper than owning and operating a car, freeing up resources for other essential needs for individuals and families. Owning and operating a bicycle typically costs around $3.00 per 100km (62 miles) traveled, while a private car can be six times more expensive, at approximately $18.00 per 100km. This includes factors like purchase price, maintenance, fuel, and insurance (ITDP, 2021). Networks of safe bicycle lanes may encourage households to replace car trips with bike trips and forgo a second or third car, leading to savings on car payments, insurance, and other car-related expenses (Grunwald et al., 2023).



The total cost of travel per 100km by mode of transportation.
(*Source: ITDP, 2022*)

AIR QUALITY AND HEALTH

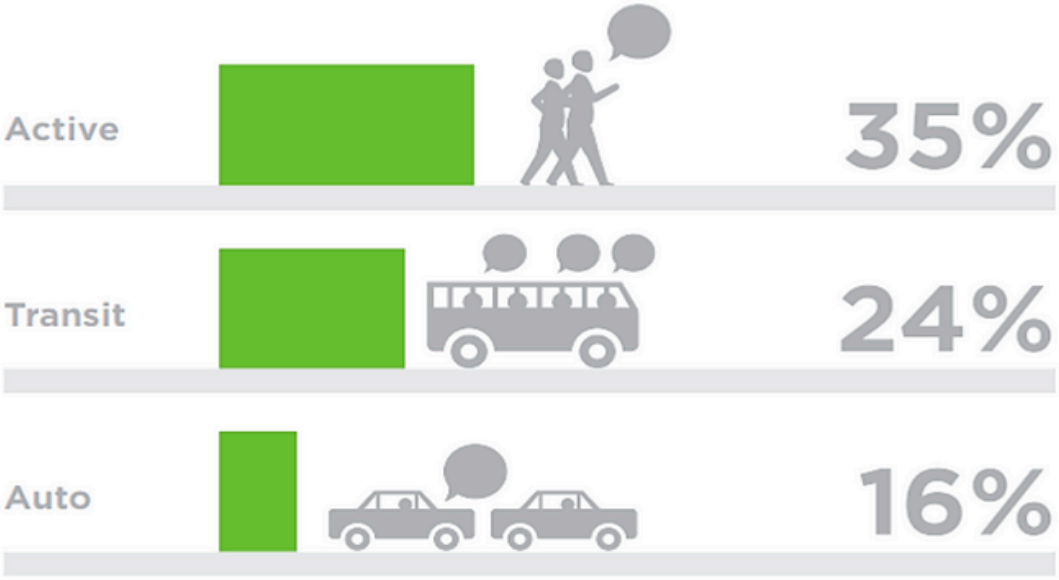
Reducing the number of vehicles on the road, especially in densely populated areas, decreases emissions of air pollutants that are harmful to human health (Litman, 2024a). If a quarter of short vehicle trips became e-bike trips in the 10 largest U.S. cities, an RMI analysis found that fine particulate pollution (PM2.5) would drop by 25% (Grunwald et al., 2023).

Driving less correlates directly with health outcomes. A per-capita VMT reduction of 20%, supported by a shift to walking, cycling and other active transportation modes, could prevent 45,000 deaths by increasing physical activity and improving public health (Warsing, et al., 2024). For example, three hours of biking per week can reduce a person's risk of heart disease by 50% (Department of General Services, n.d.).

A benefit cost analysis analyzing bicycle improvements in Portland, Oregon indicates that by 2040, $138 to $605 million in total investments will provide $388 to $594 million in estimated healthcare benefits (Gotschi, 2011).

Active transportation is linked to decreased loneliness, increased access to family and friends, and greater levels of socialization (Williams et al., n.d.). A 2023 advisory from the Surgeon General stated that the "mortality impact of being socially disconnected is similar to that caused by smoking up to 15 cigarettes a day" (HHS, 2023).

A survey conducted by City of Vancouver reveals people are more likely to have a friendly social interaction when walking or biking than when traveling by private automobile (City of Vancouver, 2016).

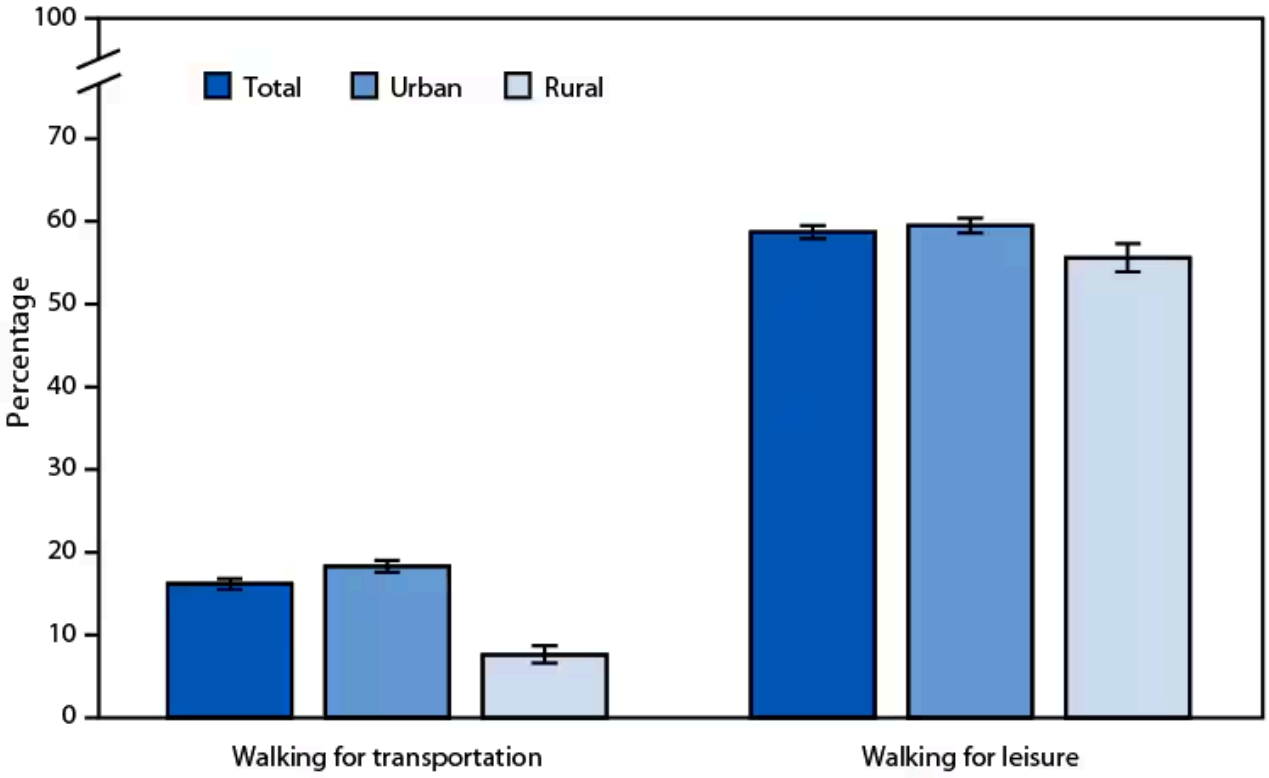


Likelihood of a Friendly Interaction During Trip (Source: City of Vancouver, 2016)

RURAL COMMUNITIES

Residents of low-density areas, especially in rural settings, are less likely to have access to safe infrastructure to walk. Yet, rural residents walk to their destinations almost as often as urban residents (CDC MMWR, 2024) and are less likely to have a variety of modes to choose from.

This lack of infrastructure causes higher rates of death and injury, especially in Tribal communities. Rural communities can build recreational bike and pedestrian trails which often have dual use as commuter routes for some trips.



Prevalence of leisure and transportation walking in the past 7 days among adults by Urban-Rural Status (Source: CDC MMWR, 2024)

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The cost to implement active transportation projects varies widely depending on the scale, scope, and location of the project.

Active transportation infrastructure has **lower installation and maintenance costs** compared to other modes:

- Roadways cost upwards of $1 million/lane km (ITDP, 2022).
- Metros (heavy rail) cost at least $50 million/km (Flyvbjerg et al., 2008).
- Bus rapid transit projects cost at least $700,000/lane km (ITDP, 2007).
- In contrast, bike lanes can range from a **few thousand dollars per mile for simple signage to $500,000 for more elaborate, off-street paths**. Similarly, pedestrian improvements can be as low as a few thousand dollars for crosswalks and traffic calming measures (Burchell et al., 2002).*

*Bike lanes were found to cost as little as **$5,000 per mile** for signing and striping only, or up to **$50,000 per mile** for designing a roadway with additional width to accommodate a lane.

Conversion of minor streets to "bicycle boulevards" was estimated to cost **$250,000 to $500,000 per mile**.

Construction of an off-street shared-use path ranges from **$500,000 to as high as $2 million per mile**. These costs can be compared with typical local road construction costs of about $2 million per mile (Burchell et al., 2002).

COST EFFECTIVENESS

Investing in bicycle and pedestrian infrastructure and street design improvements can pay dividends. A study by the Southern California Association of Governments found that for every dollar spent on bicycle and pedestrian infrastructure, over $5 is added to the regional economy (SCAG, 2016). According to an Institute for Transportation Development and Policy (ITDP) report, street redesigns with a focus on bikes, pedestrians, and bus-only lanes have resulted in 10% or more increases in revenue-generating transactions for local businesses, compared to car-focused designs (ITDP, 2022).

Multi-use paths and complete streets projects promote use of non-motorized modes, supporting regional emissions reduction goals. The Boston Region Metropolitan Planning Organization (MPO) evaluated the cost-effectiveness of statewide and MPO investment programs, finding that investing in complete streets and multi-use paths would cost approximately $4,000 and $1,900 per lane mile, or $20 and $40 per ton of GHGs reduced (Boston MPO, 2016).

Litman (2024) studied the benefits and costs of active transportation, including improved conditions for walking and cycling, reduced auto travel, land use impacts, and economic development. As an example, improving walking and cycling conditions creates an estimated $0.25 per person-mile benefit, while reduced vehicle costs and parking cost savings provide benefits of $0.23 and $0.36 per passenger-mile, respectively (Litman, 2024b).

Read more about active transportation benefits and costs here.

FUNDING OPPORTUNITIES

FHWA compiles pedestrian and bicycle activities and their likely eligibility under U.S. Department of Transportation surface transportation funding programs in this table.

FHWA's **Active Transportation Infrastructure Investment Program (ATIIP)** funds projects to provide safe and connected active transportation in active transportation networks or active transportation spines. Improvements in active transportation networks under ATIIP will expand and improve active transportation and promote it as a low-carbon transportation option.

USDOT's **Safe Streets and Roads for All (SS4A) Grant Program** was established by BIL to support regional, local, and Tribal initiatives to prevent roadway deaths and serious injuries through the safe system approach. Similar to the Zero Deaths and Safe System Program, safety improvements from SS4A will encourage mode choice by removing safety barriers to active transportation.

FHWA's **Carbon Reduction Program (CRP)** funds projects designed to reduce transportation carbon dioxide (CO_2) emissions from on-road highway sources. A variety of active transportation modes are eligible for funding including pedestrian, bicycle and shared micromobility.

FHWA's **Surface Transportation Block Grant (STBG) Program** provides funding to States for a wide variety of transportation infrastructure projects, including active transportation projects. Federal law requires 10% of these funds to be set aside for Transportation Alternatives, which include a variety of smaller-scale transportation projects like pedestrian and bicycle facilities. There is a further set aside for the Recreational Trails Program, which provides funds to develop and maintain recreational trails and trail-related facilities for both nonmotorized and motorized recreational trail uses.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including pedestrian, bicycle, and shared micromobility facilities and programs.

USDOT's **Reconnecting Communities and Neighborhoods (RCN) Program** provides grants to improve multimodal transportation access, to foster equitable development, and to remove, retrofit, or mitigate highways or other transportation facilities that create barriers to community connectivity. Projects that improve walkability, safety, and affordable transportation access are eligible for funding.

> An example of how Reconnecting Communities is improving active transportation access, mobility, and community livability can be found in the Reconnecting Communities Story Map feature of Buffalo, New York.

Department of Housing and Urban Development (HUD)'s **Community Development Block (CDBG) Program** supports community development activities to build stronger and more resilient communities. Activities may address needs such as infrastructure, economic development projects, public facilities installation, community centers, housing rehabilitation, public services, clearance/acquisition, microenterprise assistance, code enforcement, homeowner assistance, etc.

COMPLEMENTARY STRATEGIES

Employers can create a culture that embraces active transportation by offering commuter benefits for those who walk and bike to work rather than driving and parking.

Coordinated transportation planning complements active transportation when it leads to compact, mixed-use development where destinations are convenient, accessible, and support the development and use of active transportation infrastructure.

Travel demand modeling can be used to consider how the addition of active transportation infrastructure influences overall transportation patterns. Providing safe and accessible active transportation infrastructure can contribute to a shift in travel behavior, which may influence demand patterns by reducing reliance on personal vehicles, particularly for short-distance trips. This information can help justify investments in active transportation infrastructure and guide the allocation of resources to maximize the benefits of these projects.

Micromobility delivery services rely on the infrastructure established within active transportation networks. Leveraging bicycles and scooters for last-mile deliveries, these services contribute to the efficient movement of goods while complementing efforts to reduce traffic congestion and emissions in urban areas.

Shared micromobility services, such as bike and scooter-sharing programs, complement active transportation networks by offering convenient, low-barrier options for short-distance trips, thereby encouraging individuals to choose sustainable modes of transportation and reducing reliance on private vehicles.

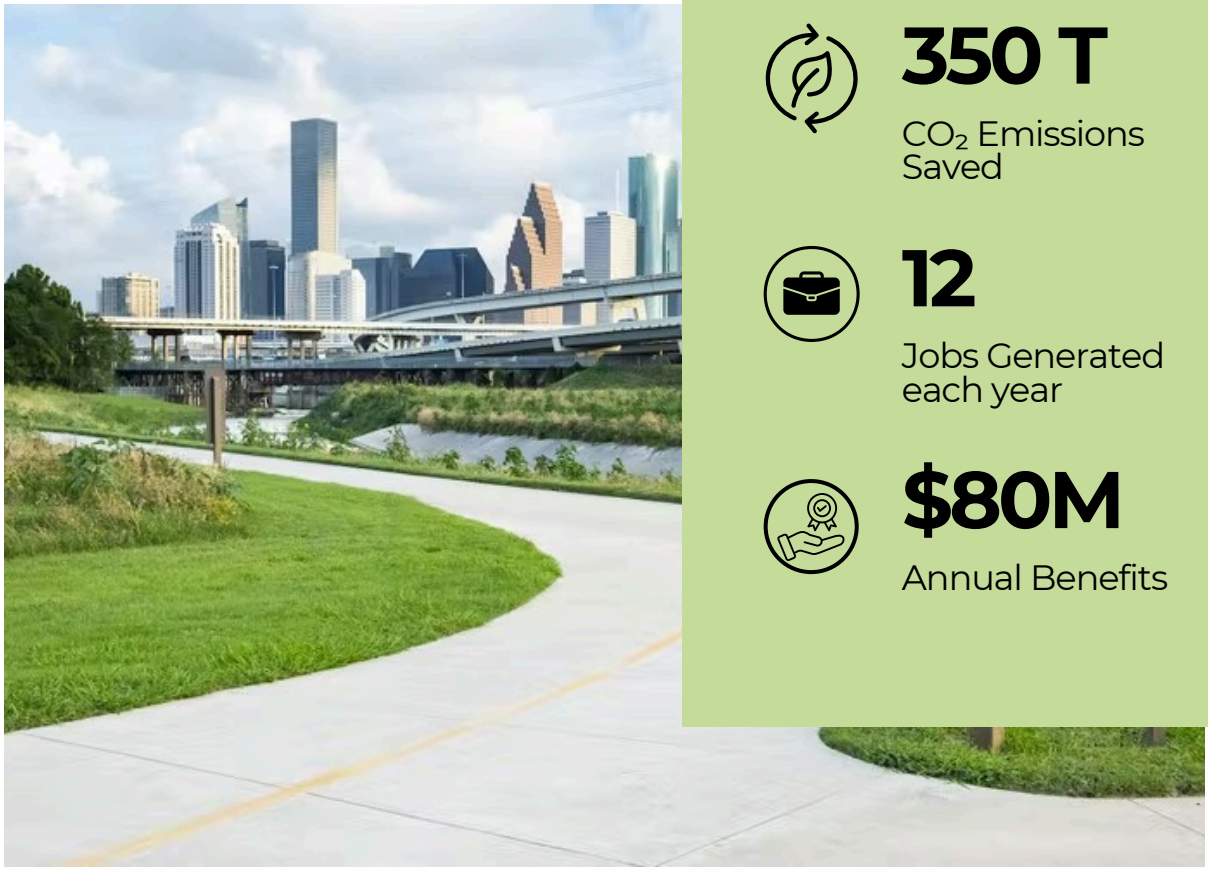
Transit-Oriented Development (TOD) can encourage active transportation by creating compact, mixed use neighborhoods with pedestrian-friendly streetscapes and bike infrastructure. Active transportation infrastructure can enhance the accessibility and attractiveness of TOD by providing residents and visitors with safe and convenient options to access transit hubs and navigate the surrounding area. TOD and active transportation infrastructure work together to promote sustainable mobility and reduce GHG emissions.

Zoning plays a key role in promoting active transportation by shaping the built environment. Zoning codes can influence the design and layout of neighborhoods, including the provision of sidewalks, bike lanes, and pedestrian-friendly infrastructure. By incorporating mixed land uses, reducing distances between destinations, and prioritizing bikeability and walkability, zoning can encourage and support active transportation options such as walking and biking. Additionally, zoning reforms may be needed to accommodate amenities like bike-sharing programs and pedestrian-oriented streetscapes, further promoting active transportation within communities.

View All Strategies

CASE STUDIES

WHITE OAK BAYOU GREENWAY - HOUSTON, TX



350 T
CO_2 Emissions Saved

12
Jobs Generated each year

$80M
Annual Benefits

The Houston White Oak Bayou Greenway (Source: Houston Parks Board).

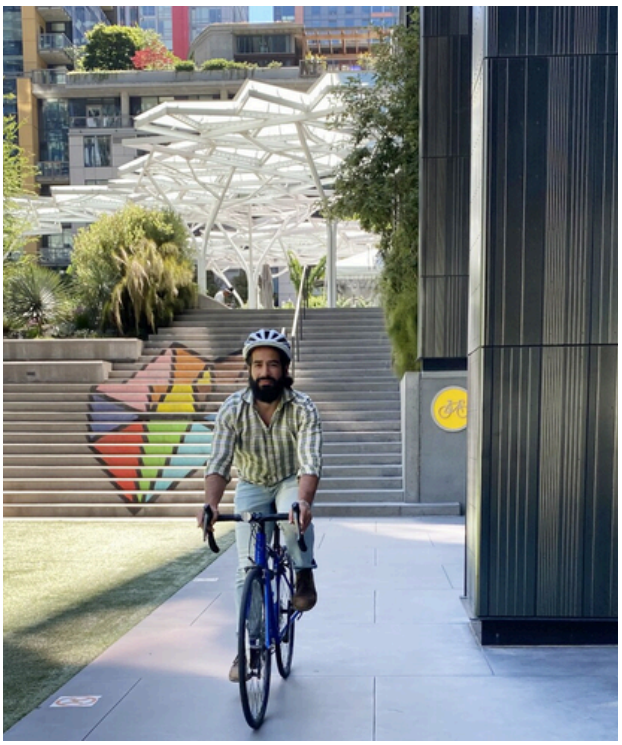
The Greenway in Houston has reduced reliance on cars, avoiding an estimated 117,000 trips annually and saving 350 tonnes of CO_2 emissions. The development of cycling optionality not only benefits the environment but also creates jobs – the Greenway is projected to generate 12 jobs per year for the next 25 years – and fosters economic activity, with potential annual benefits exceeding $80 million when considering a city-wide 2% cycling mode share.

KATY TRAIL STATE PARK - MISSOURI

Stretching 240 miles across Missouri, the Katy Trail offers a safe and scenic route for cyclists, walkers, and runners. This car-free corridor has boosted tourism, revitalized communities along the trail, and demonstrates the economic and health benefits of promoting active transportation options.

COMPLETE STREET PLAN - PUERTO RICO

Launched in 2018, Puerto Rico's Complete Streets Plan prioritizes safety and accessibility for all travelers. The plan and accompanying design guidelines were developed under three main objectives. First, the guidelines emphasize use of infrastructure to improve people's quality of life. Second, the guidelines include tools to enhance pedestrians and cyclist access to the transit system. Finally, they define components to create accessible infrastructure that is inclusive to every population group despite its individual characteristics such as age or physical conditions. The Complete Streets guidelines are expected to improve air quality, reduce congestion, and foster economic growth through more connected and vibrant places.



ACTIVE TRANSPORTATION AT AMAZON

In a bid to reduce employee drive-alone rates, Amazon fosters active transportation through their MyCommute program. Employees enjoy a $170 monthly subsidy for various options including e-bike leases, bike maintenance, and public transit. Amazon has also invested in bike infrastructure at its Seattle campuses with 3,000 bike stalls, dedicated e-bike charging stations, and on-site bike maintenance partnerships. The company's focus on active commuting has demonstrably reduced reliance on cars, contributing to a more sustainable work environment.

IMPLEMENTING ACTIVE TRANSPORTATION: **WHAT TO READ NEXT**

There is comprehensive guidance available on creating safe, efficient, and inclusive active transportation networks from design standards, engagement strategies, and proven methods for overcoming issues. Several sources are summarized under Guidance Documents in the Resources section below. More detail can also be found on the USDOT's Active Transportation page or FHWA's Bicycle and Pedestrian Program page.

Inclusive infrastructure planning and design that prioritizes safety and caters to a variety of experiences and abilities is key to encouraging broader participation in active transportation.

Implementing subsidies and offering bike-share programs can reduce upfront costs for users. Bike-sharing, in particular, offers a low-commitment option that can be less intimidating than purchasing a bike outright, especially for first-time riders.

Lack of knowledge or confidence in riding a bicycle can pose significant barriers to active transportation. Several States offer bike subsidies and targeted bike programs, including Colorado:

Source: Bike School Bentonville

Read about Colorado's tax credit and rebate program, here.

Read about Fort Collin's Targeted Bike Programs, including a Bike School, here.

Targeted outreach and culturally sensitive programming can play a vital role in closing this gap. For example, cycling education can equip users with the skills and confidence they need to navigate the streets safely.

Other inclusive design elements may include incorporating **universally understood signage** for people with varying English proficiency, bike share systems that offer **adaptive bikes**, or bike facilities that **support a wide range of user needs**, such as providing lockers for users who trip chain.

By providing accessible programs tailored to the needs of historically underserved groups, Fort Collins empowers individuals to overcome skill barriers and embrace cycling as a viable mode of transportation.

Read more about equity considerations in active transportation here: FHWA's Pursing Equity in Pedestrian and Bicycle Planning.

Read more about inclusive design for active transportation here: NACTO's Designing for All Ages & Abilities, Contextual Guidance for High-Comfort Bicycle Facilities

Active transportation infrastructure requires ongoing maintenance to ensure safety, accessibility, and usability. Regular inspections, repairs, and upkeep of bike lanes, bike share stations, sidewalks, pedestrian crossings, and other amenities are essential to preserve their functionality and appeal to users.

Read NACTO's Guidelines for the Regulation and Management of Shared Active Transportation

Active transportation that is **well integrated with transit facilities** can allow for seamless connections and address first and last-mile gaps. When connections are safe, comfortable, easy to navigate, and engaging, they become a natural extension of public transit. Investments in infrastructure like secure bike lockers at transit stations, bike repair facilities, and designated areas for storing foldable bikes, also contribute to a more convenient and user-friendly experience for active commuters.

Read more about safety considerations when connecting to transit here: FHWA and FTA's Guidebook on Improving Safety for Pedestrians and Bicyclists Accessing Transit.

RESOURCES

GENERAL RESOURCES

It's Transportation for All of Us (ITS4US) Complete Trips: This $40 million multimodal effort is led by the Intelligent Transportation Systems Joint Program Office (ITS JPO) and supported by the USDOT Office of the Secretary, Federal Highway Administration, and Federal Transit Administration jointly working to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers. This program prioritizes the needs of pedestrians and cyclists, making it easier and safer for people to choose active transportation options.

The Alliance for Biking and Walking Resource Library: This extensive online library offers hundreds of resources on bicycling and walking, including research, data, educational materials, and best practices.

CDC's Active Communities Tool: The tool consists of an action planning guide and assessment modules to help cross-sector teams create an action plan to improve built environments that promote physical activity.

FHWA Guidance: Bicycle and Pedestrian Planning, Program, and Project Development: This comprehensive guide offers a detailed framework for planning, designing, and implementing bicycle and pedestrian infrastructure projects.

FHWA Guidebook Measuring Multimodal Network Connectivity: This guidebook outlines five core components of multimodal network connectivity: Network completeness, Network Density, Route directness, Access to destinations, and Network quality. While these components are all related, the distinctions between them provide a framework for selecting connectivity measures that address specific questions. The guidebook describes analysis methods and supporting measures associated with each of these components.

U.S. Department of Housing and Urban Development, Creating Walkable and Bikeable Communities: This guide provides practical information and strategies for communities to plan, design, and implement improvements that promote walking and cycling.

National Association of City Transportation (NACTO) Urban Bikeway Design Guide: This is a leading resource for designing safe and efficient bicycle infrastructure that accommodates cyclists of all ages and abilities.

FHWA A Resident's Guide for Creating Safer Communities for Walking and Biking: This guide empowers residents to advocate for and participate in efforts to create safer streets for walking and cycling.

FHWA Pedestrian Lighting Primer, April 2022: This guide provides information on best practices for pedestrian lighting, ensuring safe and comfortable walking environments at night.

Association of Pedestrian & Bicycle Professionals' Essentials of Bike Parking: Selecting and Installing Bike Parking that Works: This resource offers guidance on selecting and installing bike parking facilities that meet the needs of cyclists and encourage bike use.

TOOLKITS AND MODELLING APPROACHES

FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Calculator Toolkit, Bicycle, Pedestrian, and Shared Micromobility Tool: The CMAQ Toolkit includes a tool specifically designed to estimate the air quality and greenhouse gas reduction benefits of bicycle, pedestrian, and shared micromobility infrastructure projects.

FHWA Active Transportation Funding and Finance Toolkit: This toolkit provides information about various funding sources and financing mechanisms that can be used to support active transportation projects.

C40 Knowledge Hub, Walking and Cycling Benefits Tool: This online tool allows users to estimate the potential health, economic, and environmental benefits of investments in walking and cycling infrastructure.

World Health Organization, Health Economic Assessment Tool (HEAT) for Walking and Cycling: This tool helps assess the health benefits associated with increased walking and cycling, including potential reductions in healthcare costs.

United Nations Environment Program Cost Benefit Analysis of NMT Infrastructure Projects: This resource provides guidance on conducting cost-benefit analyses for non-motorized transport (NMT) infrastructure projects, including walking and cycling facilities.

Smart Growth, Complete Streets Policy Evaluation Tool: This tool quantifies the Smart Growth Complete Streets Policy Framework and can help identify policy strengths, as well as areas where the policy can be improved.

FHWA, My Street Planning Tool for Improving Pedestrian Safety: My Street is a sketch-level planning tool designed to help users explore options for improving pedestrian safety in their project area.

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy.

WORKING WITH COMMUNITIES

U.S. Department of Energy's Clean Cities Coalition Network: This network supports communities in achieving cleaner air and reducing dependence on fossil fuels by promoting alternative transportation options.

FHWA's Zero Deaths and Safe System Program: This program provides resources and guidance to help communities eliminate traffic fatalities and serious injuries. Active transportation is a key component of the Safe System approach, promoting safer streets for pedestrians, cyclists, and motorists.

Environmental Protection Agency's Smart Growth: This website provides resources and technical assistance to help communities integrate active transportation into their development plans, promoting compact, walkable neighborhoods.

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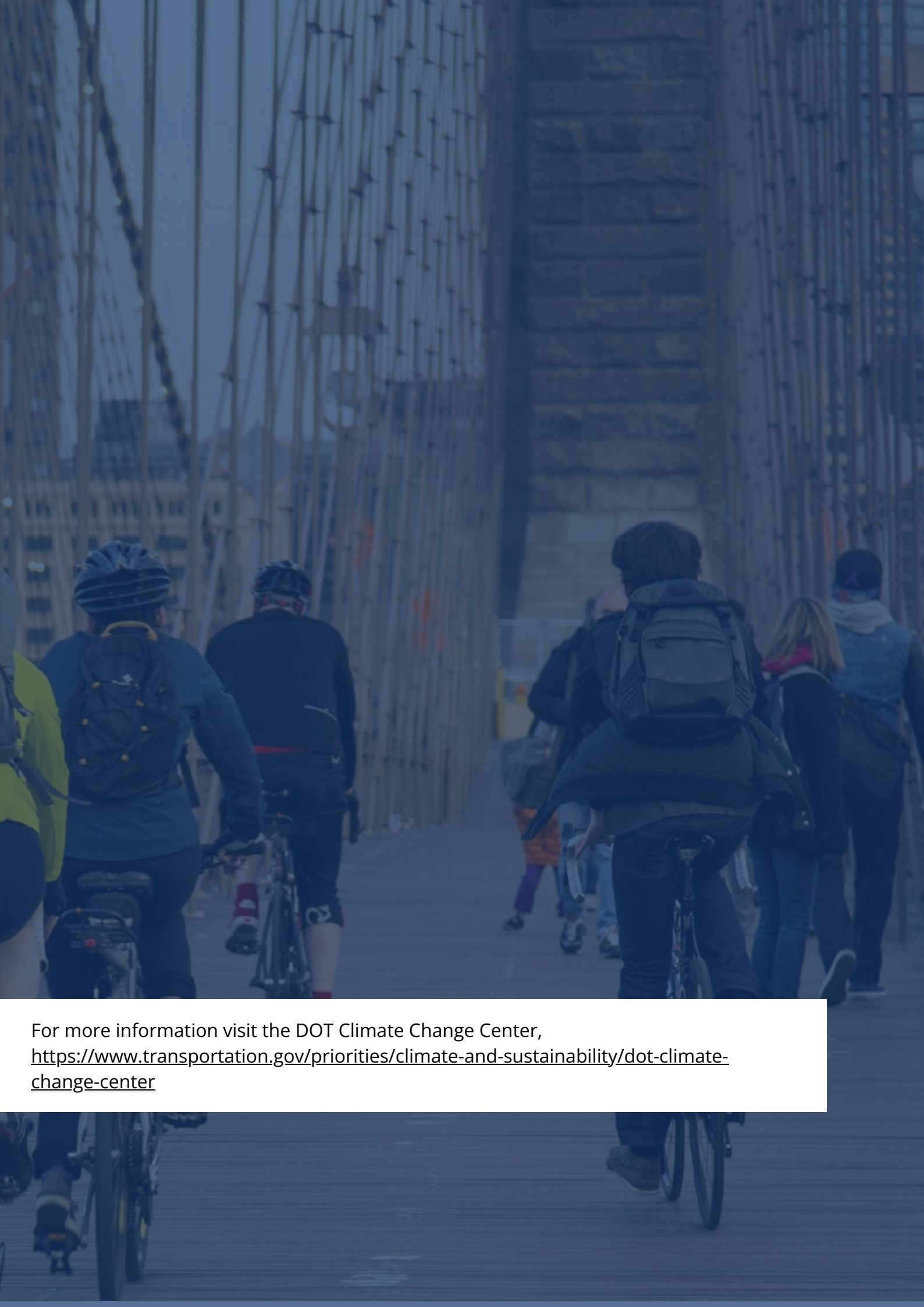
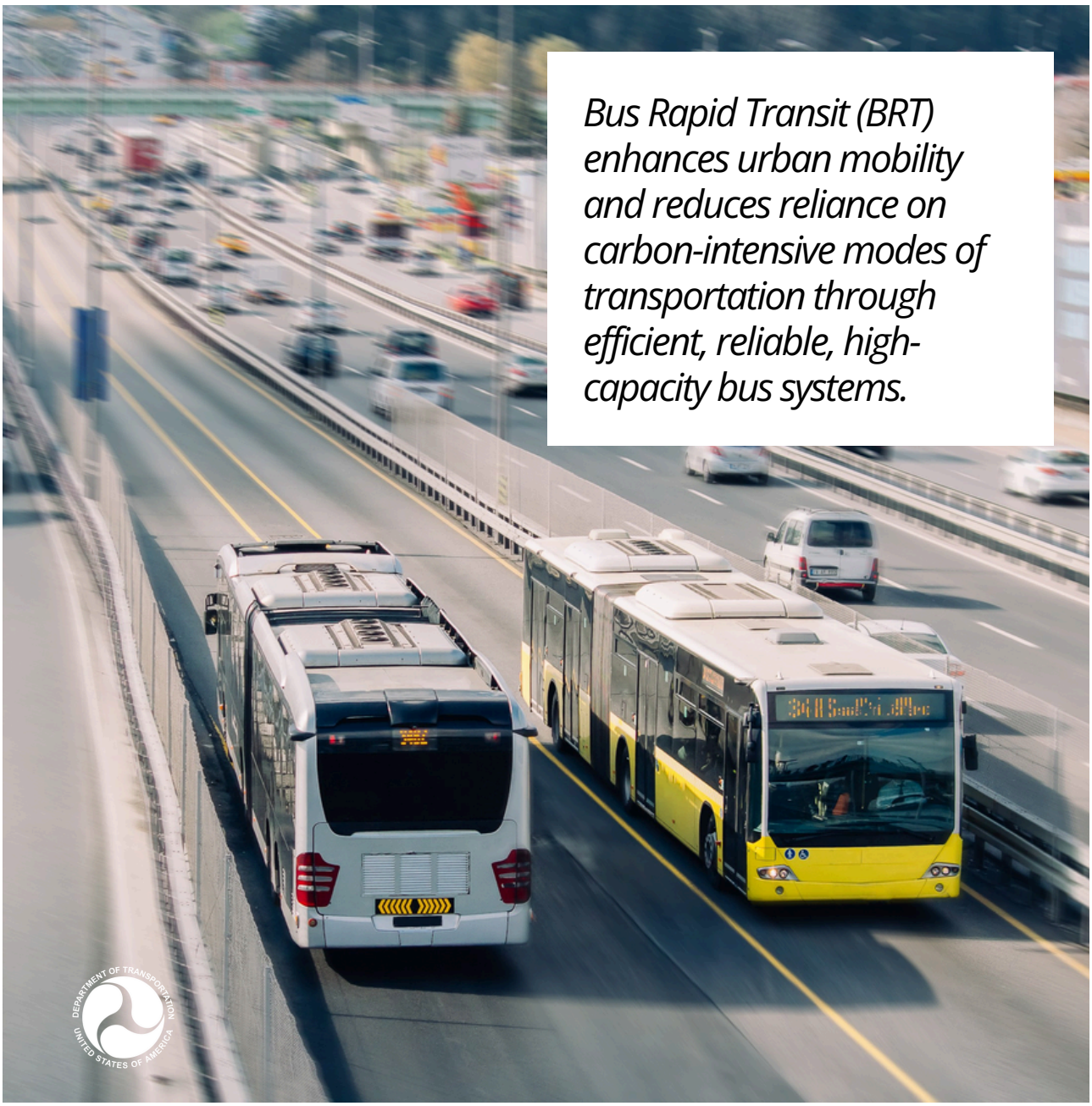


For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

BUS RAPID TRANSIT (BRT)



Bus Rapid Transit (BRT) enhances urban mobility and reduces reliance on carbon-intensive modes of transportation through efficient, reliable, high-capacity bus systems.

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OVERVIEW

Best Suited for:
Long Term & Short Term*
Urban, Suburban, Rural & Tribal*

Bus Rapid Transit (BRT) can modernize urban transportation, offering **swift, reliable, and high-capacity** bus service through dedicated lanes or rights-of-way. BRT combines the capacity and speed of a train with the flexibility, lower cost, and simplicity of a bus system. The **flexibility and lower cost** of BRT allows for greater network coverage, reaching areas that may be underserved by fixed-route bus systems. With the right combination of features, BRT circumvents common delays experienced by regular bus services, such as traffic congestion and onboard payment queues. By implementing BRT, communities can improve access to jobs, education, and essential services, fostering social equity and economic growth.

BRT systems often outperform traditional bus services in terms of schedule adherence and reliability. For example, in Port Authority of Allegheny County's West Busway Bus Rapid Transit, the Federal Transit Administration found that buses using the busway are 68% more reliable in adherence to schedule than buses operating on city and county roads.

BRT systems may incorporate features similar to a light way or subway system, including:

- Designated lane / Right-of-Way
- Off-board fare collection / All door boarding
- Bus traffic signal priority
- Sheltered waiting areas
- Platform level boarding
- Real time traveler information at stations and on vehicles shared in audible and visual formats
- Fare policies that allow free transfers between BRT and other modes

A study in Salt Lake City found that use of Transit Signal Priority systems for BRT can reduce transit time by 9% (Liu et al., 2018).

**Suitable for long-term investments, with potential for short-term benefits through phased deployment.*

**Applicable to urban, suburban, and select rural areas, depending on population density and transit demand.*

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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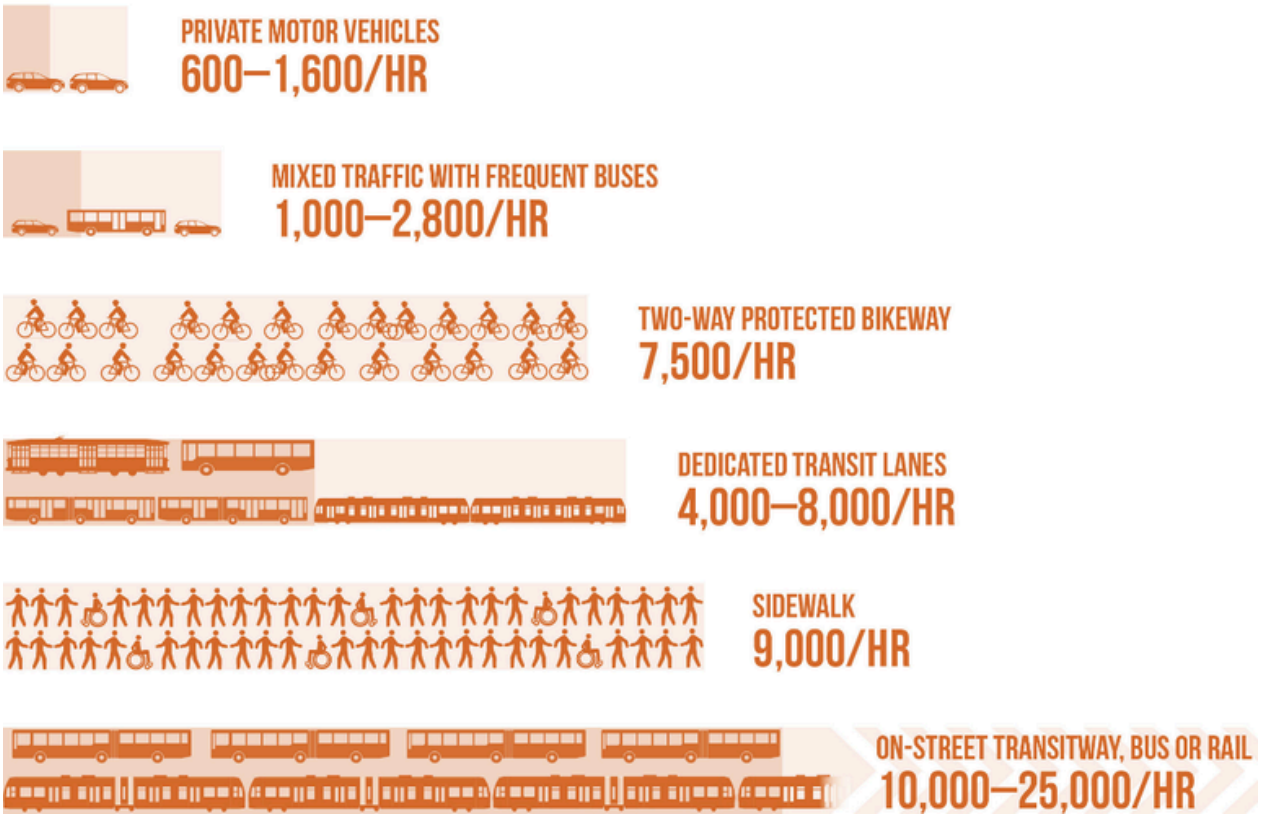
Did you know?

Increased BRT adoption in the U.S. was inspired by a trip to Brazil in the late 1990s by then FTA Deputy Administrator, Nuria Fernandez. Learn more about the history and future directions of BRT in the U.S., here.

Capacity Improvements

While a single lane of private vehicles on a city street might handle 600 to 1,600 people per hour, a dedicated bus lane can move 8,000 passengers in the same timeframe (NACTO, 2016).



The capacity of a single 10-foot lane (or equivalent width) by mode at peak conditions with normal operations (Source: NACTO, 2016).

System Performance:
BRT systems have demonstrated travel time savings when compared to regular bus services. For example,

In Boston the Silver Line Washington Street station has experienced reductions in mean running times as high as 25%, especially in the midday and PM peak periods (FTA, n.d.).

In Los Angeles, the MetroRapid achieved travel savings as high as 40%, equally attributed to fewer stops, transit signal priority, and low floor vehicles (FTA, n.d.).

Las Vegas experienced 37% (northbound) and 43% (southbound) reductions in running times compared to pre-MAX bus services; With the implementation of BRT, travel time in the BRT corridor in Pittsburgh decreased 55% (FTA, n.d.).

A steppingstone to BRT - Urban Circulators
Urban circulator systems such as streetcars and trolley lines connect urban destinations and foster the redevelopment of urban spaces into walkable mixed-use, high-density environments. Typically, an urban circulator operates regular service within a closed loop - usually 3 miles or shorter in length. Examples include the Portland Streetcar, the Denver 16th Street shuttlebus, and the Lynx LYMMO in Orlando which is a bus-based fixed guideway. Urban circulators expand access to transit while growing businesses and developing infrastructure along major corridors. As the appetite and infrastructure for transit grow alongside downtown businesses, expansion of the system into BRT is an attractive and easy option (FTA, 2015).

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

BRT SYSTEMS CAPTURE CHOICE RIDERS AND REDUCE EMISSIONS

BRT systems can capture **choice riders** resulting in a mode change away from cars, thus reducing vehicle miles traveled (VMT) and traffic-related GHG emissions, noise, and air pollution.

What is a choice rider?

Individuals whose transportation decisions are based on a combination of factors including convenience, personal preference, environmental impact, cost, and access. Choice riders are distinct from captive riders, whose options may be limited due to cost, access, or physical ability (Zhao et al., 2014).

BRT reduces the overall amount of vehicle miles travelled in a city by shifting commuters to high-capacity buses that can carry up to 160 passengers at a time (C40, 2016).

A study by the California Air Pollution Control Officers Association (CAPCOA) estimates that BRT systems can reduce GHG emissions by 13.8% compared to traditional bus routes (CAPCOA, 2021).

In 2000, the City of Bogota in Columbia launched a new BRT service, TransMilenio, with priority lanes that allow for faster bus service during peak periods. The service was estimated to have cut air pollution by as much as 40% in certain communities (Pierre-Louis, 2023).

The TransOeste BRT system in Rio de Janeiro includes over 150 kilometers of exclusive lanes. It is expected to save a estimated 107,000 tons of carbon dioxide equivalents per year, due to fuel-efficient buses and increased share of trips made by public transit across the city (C40, 2016).

SUCCESSFUL BRT IMPLEMENTATIONS ARE LINKED TO LARGE INCREASES IN CORRIDOR RIDERSHIP AND REDUCED CAR RELIANCE

Boston's Silver Line Phase I experienced a 96% increase in weekday corridor ridership, with ¼ of new riders previously using other modes (FTA, n.d.).

On Pittsburgh's West Busway, one third of riders used an automobile previously (FTA, n.d.).

Bus routes that were upgraded to BRT in King County, WA saw an average ridership growth of 35% (Stewart, Moudon, & Saelens, 2017).

Cleveland's Euclid BRT corridor saw a 60% increase in ridership after two years of operation (compared to the conventional bus route it replaced), while Eugene, OR's EmX BRT increased ridership by 74%, and the South Miami-Dade Busway in Miami, FL increased ridership by about 50% (Ingvardson, & Nielsen, 2018).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Implementing BRT systems can reduce traffic accidents and fatalities due to:

- Overall reduction in VMT. Fewer drivers on the road creates a safer environment for drivers, pedestrians, and cyclists.
- Fewer bus-vehicle interactions. Dedicated bus lanes reduce interactions between buses and other vehicles, reducing the likelihood of accidents.

A C40 analysis shows that streets with BRT systems across Latin America have experienced an average 40% reduction in fatalities and injuries (C40, 2016). The Bogota, Columbia BRT system, launched in 2000, has reduced car fatalities by 92%. Soon after launch, approximately 11% of riders identified as former drivers, suggesting that BRT systems, when designed thoughtfully with accessibility elements and connections to active transportation, can influence mode choice and reduce traffic fatalities (Pierre-Louis, 2023).

BRT corridor development creates an opportunity to improve cyclist accessibility, safety, and comfort. In the case of the new M15 select bus service (SBS) in New York City, bicycling increased 18% to 177% due to bicycle safety improvements implemented in conjunction with SBS infrastructure (Beaton et al., 2012).

In the U.S., for every 100 million person-trips, one study found that fatality rates for car occupants are 23 times higher than those for bus occupants (Beck, et al., 2007). Other research found fatality rates to be 66 times greater for car occupants than bus occupants per passenger-mile (Savage, 2013).

A study of 10 bus routes in Montreal, Canada found that the rate of fatally or severely injured vehicle occupants is 6 times greater for car occupants than for bus occupants (Morency, et al. 2018[AMM3]).

The same study found that the rates of pedestrian and cyclist injuries are also significantly greater for car travel (4.1 times) than bus travel (Morency, et al. 2018).

ACCESSIBILITY AND EQUITY

BRT enhances mobility options by improving accessibility and reducing travel times, which can be especially beneficial for individuals who lack access to a car or for whom driving would be impossible due to cost or disability (Nelson & Ganning, 2015).

BRT systems can save users travel time and make every-day destinations more accessible. For example, the Metrobus in Mexico city has been shown to reduce travel times by up to 50% in high-traffic corridors, while the BRT corridors in Buenos Aires have cut travel times by 20-40% on average (C40, 2016).

Thoughtful system design and amenities can help maximize the benefits of BRT. Features that can make BRT a more attractive mode choice include: (ELPC, 2024; C40, 2016)

- Dedicated busways separated from other vehicle traffic
- Off-board fare collection
- Accessible and bright, inviting stations
- Well-lit stops with shelter and heating
- In cabin amenities, such as free Wi-Fi and charging ports

The ITDP's BRT SCOPE tools shows how better BRT design can contribute to higher ridership and reduced emissions.

BRT systems with off-board fare collection can reduce travel time and improve passenger experience, especially for passengers with young children, people with disabilities, and elderly riders. In its BRT Scorecard, The Institute for Transportation and Development Policy, gives the highest scores to BRT systems with fare-free services and turnstile-controlled fare collection (ITDP, 2024).

The 9.6-mile-Silver Line in Grand Rapids, which launched in 2014, serves the highest employment concentrations in the area. It offers accessible boarding platforms, snow-melting sidewalks, bike racks, and free Wi-Fi on buses. It has helped relieve congestion in the Central Business District and reduced travel time from 47 minutes to 27 minutes (ELPC, 2024).

The Minneapolis-St. Paul's METRO BRT system runs up to 25% faster than local buses and has seen ridership increase by 115% between 2022 and 2024. The BRT stations including lighting, on-demand heat, and emergency phones and cameras (ELPC, 2024).

COST SAVINGS

Transportation is the second-largest household expense for low-income households, after housing (Bureau of Transportation Statistics, 2023). Investments in BRT can reduce transportation costs by reducing the need for car maintenance, fuel, and parking costs. Households that transition from car ownership to using public transportation, walking, and biking can save nearly $10,000 per year (APTA, 2020).

Read more here about potential savings from using public transit vs. a personal vehicle for the top 20 cities by ridership (APTA, 2023).

ECONOMIC GROWTH

BRT investments often stimulate economic development along transit corridors, creating new job opportunities and in some cases revitalizing urban neighborhoods (Nelson & Ganning, 2015).

BRT infrastructure investments have the potential to catalyze positive land development effects, fostering mixed-use development and creating vibrant, walkable communities along transit corridors. The table below details benefits seen in four different cities.

BRT Land Development Benefits (Source: FTA, 2015)

City	Benefits
Pittsburgh	$300M in development around stations
Ottawa	$700M in development around stations
Boston	$650M in development occurred along the Washington Street corridor
Brisbane	+20% gain in residential values near stations, initiation of several joint development projects

AIR QUALITY AND HEALTH

BRT systems are known to increase transit ridership and increase the number and type of options available for a local trip that might otherwise be made by single occupancy vehicles, thus reducing overall transportation-related pollutants that negatively impact human health (Carrigan et al., 2013).

BRT systems that use alternative fuel buses, including electric buses, have improved in-cabin air quality, compared with diesel buses. For example, a study of Mexico City's BRT system found that peak in-cabin PM2.5 concentrations decreased by 35 to 80% when buses were upgraded from diesel to electric versions. These air quality improvements are attributed to lower emissions and closed, air-conditioned cabins (Paniagua et al., 2023).

BRT systems that connect with active transportation infrastructure can promote increased physical activity. Features such as clearly marked pedestrian crossings, curb extensions, and dedicated bike lanes make it easier for people to use active transportation in conjunction with transit (CDC, 2023).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

BRT ***capital costs can vary significantly***, some examples include:

- Franklin Corridor in Eugene, Oregon costing $4.4 million / Km (FTA, 2009).
- Orange Line in Los Angeles, California costing $16.2 million / Km (FTA, 2011).
- Purchase costs for higher end BRT vehicles can range from $370,000 to $1.6 million, depending on the size and propulsion technology (FTA, 2015).

Purchase costs for higher end BRT vehicles can range from $370,000 to $1.6 million, depending on the size and propulsion technology (FTA, 2015).

Costs for Intelligent Transportation Systems (ITS) BRT components can vary widely, ranging from $100,000 to more than $1,000,000 per mile. The USDOT's Intelligent Transportation Systems Joint Program Office maintains a cost database with cost estimates for ITS deployments.

> In 2022 Antelope Valley in northeastern California became the first municipality to unveil an all-electric bus fleet. The upgrade cost roughly $80 million, or about $1 million per bus, but brought significant cost savings. The transit authority notes that the electric fleet's first 10 million miles avoided $3.3 million in fuel costs (Pierre-Louis, 2023).

COST EFFECTIVENESS

Construction time for a BRT project is typically less than 18 months compared to a light rail transit (LRT) project which ranges from about 2 to 3 years, because a LRT system is more complex than BRT (Taotao & Nelson, 2010).

BRT can be a cost-effective addition to a city's transit network, requiring a lower initial investment compared to traditional rail-based systems. This characteristic can be especially important in smaller to medium size cities that are seeking to enhance their transit services but may not have the financial resources to construct a more expensive rail system (Vuchic, 2005).

BRT and light rail transit (LRT) Development Costs (ITDP, n.d.).

Based on recent BRT and light rail corridor development costs in the United States, on average, BRT can be 7 times more affordable than light rail per mile. That's 25 miles of BRT infrastructure for the same cost of less than 4 miles of light rail (Kauppila, 2016).

BRT-like design features can also be deployed to create a less expensive, yet still effective, rapid bus system under certain circumstances. For example, New York City's Select Bus Service deployed features such as bus lanes, transit signal priority, and off-board fare payments, which decreased travel times by about 20%, and increased ridership by 10-20% (NYCDOT, n.d.).

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

FTA's **Urbanized Area Formula Funding program** provides transit capital and operating assistance and transportation-related planning in urbanized areas.

FTA's **Grants for Buses and Bus Facilities** Program supports state and local efforts to buy or modernize buses, improve bus facilities, and support workforce development.

FHWA's **Congestion Mitigation and Air Quality (CMAQ) Improvement Program** provides funds to States for transportation projects designed to reduce traffic congestion and improve air quality, particularly in areas of the country that is or was designated nonattainment for certain national air quality standards.

FHWA's **Carbon Reduction Program (CRP)** funds projects designed to reduce transportation carbon dioxide (CO_2) emissions from on-road highway sources.

FHWA's **Surface Transportation Block Grant (STBG) Program** provides flexible funding that may be used by States and localities for projects to preserve and improve the conditions and performance on any Federal-aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects.

FTA's **State of Good Repair Grants Program** provides capital assistance for maintenance, replacement, and rehabilitation projects of high-intensity fixed guideway and motorbus systems to help transit agencies maintain assets in a state of good repair in urbanized areas.

FTA's **Capital Investment Grants (CIG)** program funds transit capital investments including new and expanded rapid rail, commuter rail, light rail, streetcars, bus rapid transit, and ferries.

FTA's **Better Utilizing Investments to Leverage Development (BUILD) Transportation Grants Program** funds investments in transportation infrastructure, including transit.

FTA's **Buses and Bus Facilities Discretionary Grants** assist in the financing of buses and bus facilities capital projects, including replacing, rehabilitating, purchasing or leasing buses or related equipment, and rehabilitating, purchasing, constructing or leasing bus-related facilities.

FTA's **Low or No Emission (Low-No) Vehicle Program** supports state and local efforts to buy or modernize buses, improve bus facilities, and support workforce development.

The Build America Bureau's **Transportation Infrastructure Finance and Innovation Act (TIFIA)** program provides credit assistance for qualified projects of regional and national significance. Many large-scale, surface transportation projects - highway, transit, railroad, intermodal freight, and port access - are eligible for assistance.

COMPLEMENTARY STRATEGIES

Enhancing pedestrian and cycling infrastructure along BRT corridors encourages multimodal connectivity and promotes healthier, more sustainable travel options.

Providing shared mobility (e.g., bikeshare, scooters) at or near the BRT stations will help improve first-/last-mile options for BRT passengers and may encourage more linked trips.

Coordinating land use planning with BRT investments facilitates compact, mixed-use development around transit hubs, maximizing ridership and minimizing sprawl.

TRANSIT SYSTEM INTEGRATION

Implementing fare integration schemes across transit modes streamlines the passenger experience.

COMMUTER BENEFITS

Commuter benefits can complement bus rapid transit by encouraging more people to use public transit for their commute. Increased ridership on bus rapid transit systems can lead to greater efficiency and effectiveness of the service as well as potential expansion to serve more areas and accommodate growing demand.

View All Strategies

CASE STUDIES

EVERETT BRT (EVERETT, MASSACHUSETTS)

Source: Barr Foundation

In the Greater Boston region, the Everett BRT pilot showcased the effectiveness of bus rapid transit elements in improving transit efficiency and rider experience. By creating bus priority in Arlington, Everett, Cambridge, and Watertown through dedicated and shared bus and bike lanes, queue jumps, transit signal priority, and platform level boarding, the pilot demonstrated significant improvements in bus travel times and reliability. Additionally, the incorporation of art installations into BRT stations, such as flower bombs and curated bus shelter art, enhanced the aesthetic appeal of transit infrastructure, improving the overall rider experience and fostering community engagement with public transportation initiatives.

Source: Barr Foundation

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RAPID RIDE (KING COUNTY, WASHINGTON)

King County Metro's BRT system shows significant time savings of up to 20% over previous local bus routes. Utilizing semi-exclusive bus lanes, queue jumps, and off-board fare collection, King County Metro ensures reliable service. Collaboration with local stakeholders prioritizes equity and connectivity, resulting in higher ridership and satisfaction levels, setting a benchmark for successful BRT deployment.

Source: Pace Bus

PACE SUBURBAN BUS (CHICAGO, ILLINOIS)

Pace Suburban Bus operates the Pulse BRT system in Chicago's suburban areas, where traffic congestion can be a significant challenge. To address this, the system incorporates features like Transit Signal Priority (TSP) and curb extensions to improve service reliability and efficiency. Additionally, on highways like I-55, buses utilize bus-on-shoulder (BOS) operations to bypass traffic congestion, ensuring smoother and more reliable service. These measures have led to significant improvements, with on-time performance increasing from around 65% to 92% with BOS operation on I-55, and corridor bus ridership increasing by 600%.

IMPLEMENTING BUS RAPID TRANSIT: **WHAT TO READ NEXT**

The FTA's Bus Rapid Transit Resources page provides a number of case studies on US cities that have implemented BRT systems, including Los Angeles, Las Vegas, Eugene, Miami, and Pittsburgh. This includes an overview of the costs of these systems, and some of the design considerations that go into building a BRT route.

The Institute of Transportation and Development Policy produced a report on guidelines for implementing BRT systems in US cities. The report goes over funding strategies that different cities have use to construct BRT systems, including local funding and applicable federal grants. It also provides general guidance on the timelines associated with BRT implementation.

FTA's Characteristics of Bus Rapid Transit for Decision Making report provides a variety of information on items that can be considered when designing and implementing a BRT system. This includes capital aspects of a BRT project, such as vehicle type and station designs, and operational aspects, such as fare collection and intelligent transportation systems.

With proper planning and stakeholder engagement, municipalities can expedite the deployment of BRT corridors to meet evolving transit demands. Check out the ITDP's BRT Planning Guide for more information on the BRT planning process, including project initiation, demand analysis, public participation, and cost-benefit analysis.

RESOURCES

GENERAL RESOURCES

Federal Transit Administration, Bus Rapid Transit Resources: This webpage is a comprehensive repository of BRT information, including examples, research, evaluation, and tools.

U.S. DOT, Characteristics of Bus Rapid Transit for Decision-Making: This resource provides comprehensive information for transportation planners and decision makers to develop and evaluate BRT. The resource includes the main elements of BRT, system performance measures, and system benefits. Sub-topics include travel time, reliability, identity and image, safety and security, capacity, ridership, cost effectiveness, operating cost efficiency, land development, and environmental quality considerations.

U.S. DOT, The Characteristics of Accessible Bus Rapid Transit: This white paper highlights elements of BRT that affect accessibility.

Institute for Transportation and Development Policy, BRT Planning Guide: This guide provides a roadmap for BRT planning, outlining key steps and considerations for successful implementation.

Institute for Transportation and Development Policy, BRT Planning Guide Webinar Series: This webinar series goes into specific aspects of BRT planning, expanding on the information in the guide through focused webinars.

Institute for Transportation and Development Policy, Getting to BRT: An Implementation Guide for U.S. Cities: This guide offers practical guidance specifically tailored to US cities looking to implement BRT systems.

TOOLKITS AND MODELLING APPROACHES

Institute for Transportation and Development Policy, BRT Standard: This standard is both a framework for understanding BRT and an evaluation tool for BRT corridors based on international best practices.

Clean Air Initiative for Asian Cities (CAI-Asia) and Institute for Transportation and Development Policy (ITDP), Transport Emissions Evaluation Model for Projects (TEEMP) BRT: This model can estimate the potential impact of BRT systems on transportation emissions, allowing planners to assess environmental benefits.

The American Cities Climate Challenge, Transit Priority Toolkit: This toolkit provides cities an easy-to-use resource to engage with internal staff, stakeholders, decision makers, and the public about transit priority projects.

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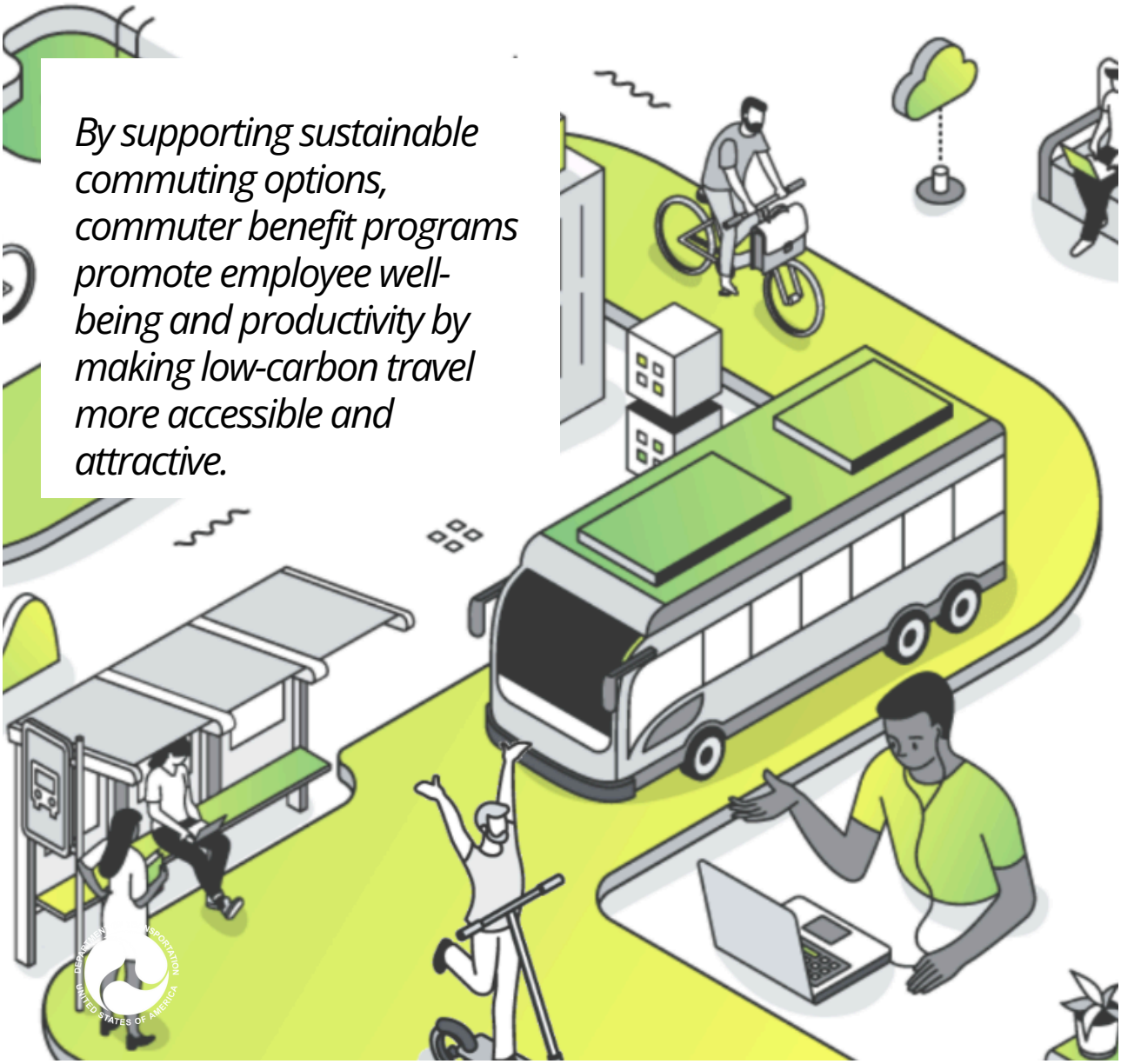
For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

COMMUTER BENEFITS

By supporting sustainable commuting options, commuter benefit programs promote employee well-being and productivity by making low-carbon travel more accessible and attractive.



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OVERVIEW

Best Suited for:
Long Term
Urban, Suburban, Rural & Tribal

Many employers offer pre-tax commuter benefits as part of an employee's compensatory package to provide cost savings and support recruitment and retention efforts. Commuter benefits can support transportation decarbonization goals by providing financial benefits to **employees that walk, bike, or take public transit.**

Many employers provide parking spots for employees. Parking "cash out" is a strategy that encourages employees that use lower carbon modes for their commute and reduces office overhead costs by reducing demand for parking spaces. Employers who offer free or subsidized parking at work can instead offer employees an equivalent cash payment, tax-free transit benefit, or tax-free vanpool benefit.

While there is no federal law mandating that employers or organizations of a certain size offer pre-tax commuter benefits, such as transit benefits to their employees, Section 132(f) of the IRS Code allows for employers to offer nontaxable qualified transportation fringe (QTF) benefits. As State and local governments are looking for opportunities to reduce transportation emissions and commuter costs, transit benefits in line with Section 132(f) have been enacted across the country.

For example, the State of Illinois recently established a commuter benefit program, which took effect in January 2024. The new Transportation Benefits Program Act requires employers with more than 50 full-time employees located within a half-mile of a fixed route transit service inside the six-county RTA region, to offer pre-tax transit benefits to their employees (Chicago Transit Authority, n.d.).

Many government employees, including Federal employees, are eligible for commuter benefits, including transit subsidies, rideshare opportunities such as vanpools, and bicycle benefits. According to an FHWA study, government agencies in California, Rhode Island, and Washington, DC require employers to offer parking cash-outs to their employees, while those in Maryland, Colorado, Delaware, Connecticut, Oregon, and New Jersey, encourage employers to implement parking cash-out programs through tax codes.

Employee benefits or that support mode choice and low-carbon trips may include:

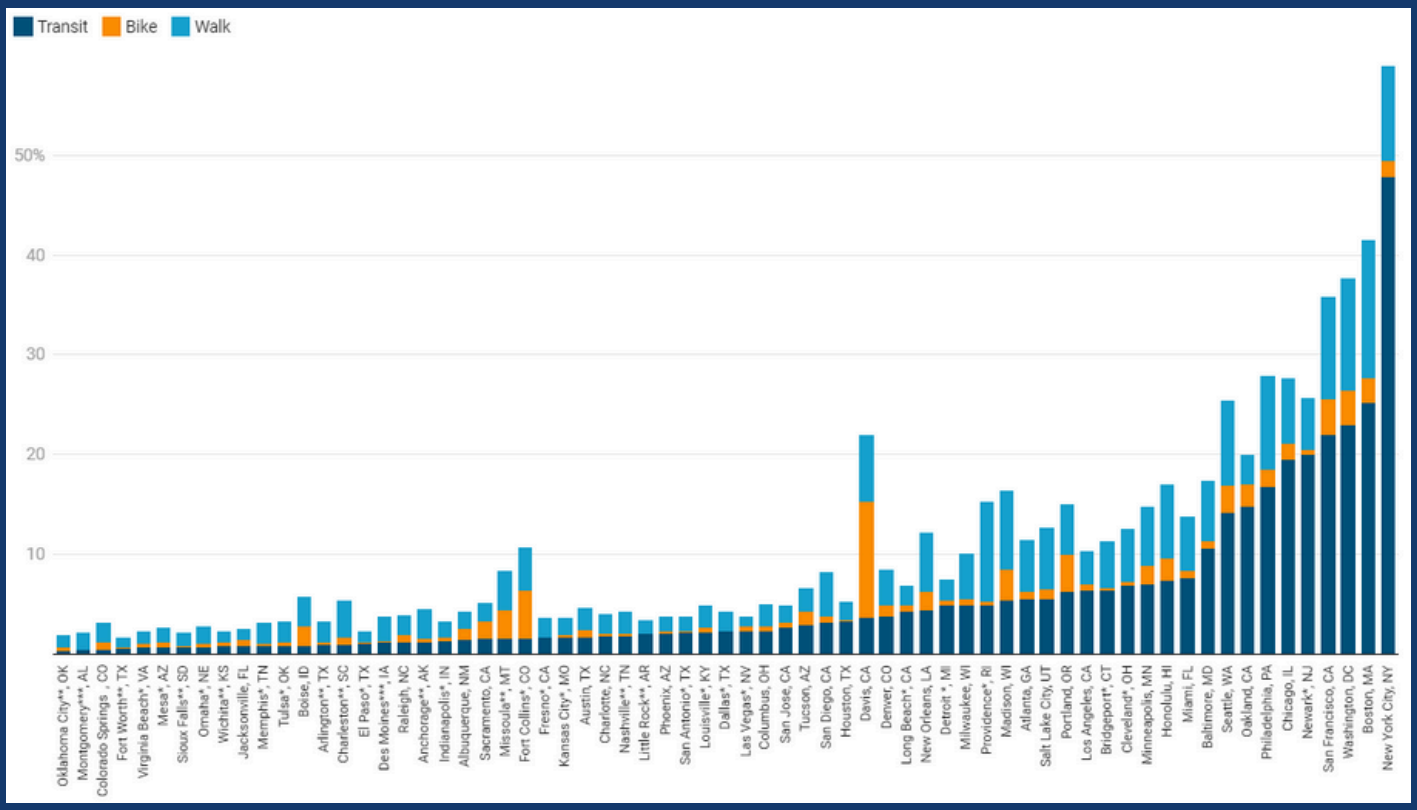
- *Provide financial incentives (subsidies) for transit passes, carpools, bicycle costs, rideshare, and bikeshare.*
- *Implement carpool matching programs to connect employees living in close proximity.*
- *Offer flexible work start and end times to avoid peak traffic congestion.*
- *Encourage telecommuting or remote work options when feasible.*
- *Install secure bike parking facilities with weather protection and lockers.*
- *Offer on-site showers and changing facilities to encourage cycling or walking.*
- *Offer parking cash-outs for employees not using office parking facilities.*

Bike parking facilities with whether protection and lockers can support bike-to-work initiatives.

A bike survey in NYC indicated the second most common reason that non-commuting cyclists do not commute by bike is because of lack of safe storage at work (NYC Department of City Planning, 2007).

Did you know?

The following cities have the highest percentage of employees biking to work.



Source: The League of American Bicyclists

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GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

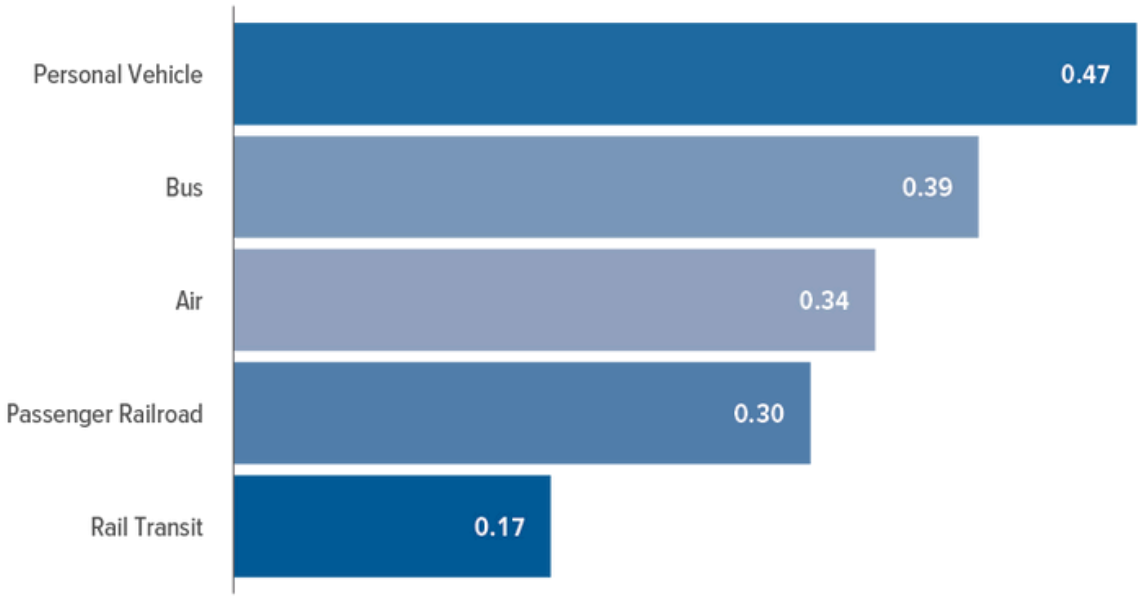
In the U.S., Personal Occupancy Vehicles (POVs) are the primary contributor to GHG emissions within the highest emitting sector, transportation. Commuting to work is often the most frequent and longest recurring trip that Americans make. Commuter benefits have the potential to change commuting behavior toward alternative transportation modes, such as transit (Gutman, 2017).

The California Air Pollution Control Officers Association provides estimates of GHG emissions benefits for commuter benefit programs (CAPCOA 2021):

- Voluntary commute trip reduction programs can reduce GHG emissions from project/site employee commute vehicle miles traveled (VMT) by up to 4% whereas a mandatory program could reduce GHG emissions by up to 26%.
- A subsidized or discounted transit program can reduce GHG emissions from employee/resident vehicles accessing the site by up to 5.5%.
- Providing an employer-sponsored vanpool can reduce GHG emissions from project/site employee commute VMT by up to 20.4%.

> Commuter benefit programs can be designed to encourage alternatives to car commuting, including public transit. In 2019, CO2 emissions from personal vehicles averaged 0.47 pounds per passenger-mile, while emissions from rail transit were only 0.17 pounds per passenger-mile (CBO, 2022).

Findings from the Puget Sound Regional Travel Survey show the VMT reduction benefits of Washington State's Commute Trip Reduction Law, which requires employers to offer travel demand management (TDM) programs. Transit-related benefits (free or subsidized passes) are associated with higher rates of commuting by public transport, active transportation, and carpooling relative to driving along. Workers with transit benefits drive 3.16 fewer miles per trip on average, while workers with free workplace parking drive 3.13 more miles per trip. Similar trends are seen for non-work trips – the availability of free workplace parking encourages more driving outside of work (Shin, 2020).



Average Carbon Dioxide Emissions per Passenger-Mile, by Mode of Transportation, 2019 (CBO, 2022).

FHWA analyzed reductions in daily citywide commute VMT by commuter benefit scenarios and found that local parking cash-out related ordinances would have the most significant impact on VMT and subsequent congestion and emissions.

City	S1: Monthly Cash-Out	S2: Monthly Commuter Benefit	S3: Monthly Cash-Out + Pre-Tax Transit Benefit	S4: Daily Cash-Out + Pre-Tax Transit Benefit	S5: Eliminate Parking Subsidies + $5 Non- Single Occupancy Vehicle (SOV) Subsidy
Boston/Cambridge, MA	1.0M	0.1M	1.0M	1.8M	2.8M
Chicago, IL	2.0M	1.3M	2.4M	3.3M	6.6M
Houston, TX	1.7M	1.2M	1.8M	4.1M	10.4M
Indianapolis, IN	0.6M	0.3M	0.6M	1.6M	2.6M
Los Angeles, CA	3.5M	2.2M	3.5M	6.8M	10.8M
New York, NY	1.2M	0.4M	3.7M	4.3M	12.6M
Philadelphia, PA	1.6M	1.2M	1.8M	2.7M	4.3M
San Diego, CA	1.1M	0.6M	1.1M	3.0M	4.8M
Washington, DC	0.5M	0.2M	0.6M	1.2M	2.6M

*M = million

Raw reductions in commute VMT by scenario and city. Source: FHWA, 2023.

PARKING CASH-OUT STRATEGIES CAN REDUCE VMT AT THE NATIONAL AND LOCAL LEVELS

A FHWA study on state-level strategies including parking cash-outs projects a 6.6% decrease in the total U.S. VMT from a cash-out policy scenario modeled for employers with 10-99 employees, daily cash-out for employers with 100 or more employees, and no cash-out requirement for employers with fewer than 10 employees.

In a study of the parking cash-out impact on nine cities across the U.S., results suggest 6 out of 9 cities projected a 5 to 25% decrease in commute-related VMT (Abou-Zeid et al., 2023).

A 2009 study found a 12% decrease in single occupancy vehicle use across 7 employers that implemented parking cash-out programs in the St. Paul-Minneapolis region (Van Hattum, 2009).

In Seattle, researchers found employee parking demand decreased by 10% with the introduction of parking cash-out options (Glascock, Cooper, and Keller, 2003).

RIDESHARING REDUCES VMT AND ALLEVIATES CONGESTION

Carpooling and vanpooling can reduce vehicle trips and parking demand.

Many large employers choose to implement travel demand management (TDM) programs featuring carpool/vanpool and ride matching incentives and services as key strategies to increase their Average Vehicle Ridership (AVR) scores. AVR scores improve if there are more people than vehicles traveling to a work site (Texas A&M Transportation Institute, 2024a).

A study of parking cash-out programs offered by 7 employers in the St. Paul-Minneapolis area found a 12% decrease in single occupancy vehicle travel following implementation (Van Hattum, 2009).

A 2016 study on the impacts of ride sharing on vehicle miles traveled in the United States noted the combination of a moderately used regional dynamic ride sharing system, along with a 10-30% increase per mile cost of vehicle travel, can reduce 11-19% of VMT across the country (Rodier et al., 2016).

Bellevue City Hall in Washington introduced a ride sharing program to its employees with discounted carpool parking and subsidized vanpooling. The ride sharing program decreased vehicle ridership by 30% across 650 employees (TTI, 2024b).

In Washington, D.C., the Pool Rewards project provided participants with $1 each way for each day they carpooled to work. A three-month pilot in 2010 resulted in 293 fewer daily auto trips and a daily VMT reduction of over 9,000 miles per day (Texas A&M Transportation Institute, 2024a).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Commuter benefits that change commutes from personal vehicles to other modes, such as public transit and bicycle, help decrease traffic volumes during peak commute periods. Less congested streets that also maintain low speeds can decrease the likelihood of accidents and improve overall transportation safety (Retallack and Ostendorf, 2019).

An FHWA analysis of commuter benefit programs found that citywide VMT reductions following program implementation would reduce fatal and incapacitating injury crashes up by up to 30 per year. Although estimates from this analysis may seem relatively small, any reductions in fatalities or injuries on roadways reflect meaningful safety improvements (FHWA, 2023).

ACCESSIBILITY AND EQUITY

Commuter benefits help break down barriers to job access, removing car ownership as a pre-requisite for maintaining employment (Andersson et al., 2014).

City and regional ordinances that require employers to eliminate subsidized parking benefits and instead offer non-SOV commute benefits advance transportation equity by eliminating the false free cost of parking. Free parking acts to subsidize automobile use, and can subsequently increase congestion, pollution, emissions, and crash risk (FHWA, 2023).

In a 9-city study of commuter benefits, FHWA found that any policies that expand the baseline number of employees considered for benefits (beyond only free parking) would have positive equity implications. However, low income groups are significantly less likely to be offered transit benefits compared to higher income groups, and higher income groups experience higher rates of workplace transit benefits. Programs that target lower income individuals or particular sectors/employers can enhance the equity of benefit offerings (FHWA, 2023).

ECONOMIC GROWTH

Commuter benefits programs can provide savings for both employers and employees. Employers can reduce their payroll taxes and attract and retain more talented employees by offering transportation benefits. Employees can lower their monthly commute expenses (NYC Commuter Benefits Law).

When commuter benefits lead to greater investment in transit, there can be even greater benefits to economic growth. Investment in transit can yield 49,700 jobs per $1 billion invested, and offers a 5 to 1 economic return (APTA, 2020).

AIR QUALITY AND HEALTH

Commuter benefits can encourage employees to choose from personal vehicles to other modes. Reducing the number of emissions-emitting vehicles on the road (especially in densely-populated areas) will decrease air pollutants that are harmful to human health (Litman, 2024).

Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways and ports (USEPA, 2014; Jbaily et al., 2022).

RURAL COMMUNITIES

In some rural areas, residents may need to commute longer distances to access employment opportunities, especially if there are limited job options locally. Commuter benefits, such as those that subsidize public transportation or carpool/vanpool can help make these commutes more affordable and less carbon intensive.

Per capita vehicle ownership and VMT tend to be higher in rural areas, while walking, cycling and public transit travel tend to be higher in urban areas. Rural households tend to drive relatively high annual miles and have relative low annual incomes, making them more sensitive to changes in fuel prices and other commuting costs (Litman, 2024b).

COST SAVINGS

Employees can save as much as 40% on monthly transit or vanpool costs when they choose the San Francisco Bay Area Commuter Benefits Program pre-tax benefit option (MTC, 2024).

Commuter benefit programs can reduce VMT and congestion, saving commuters valuable time each day. FHWA found citywide dollar savings for all commuters due to delay reductions ranging from $6M to over $120M (FHWA, 2023).

Commuter benefits programs can save employees money otherwise spent on personal vehicle expenses, such as car maintenance, fuel, and parking costs.

City	Scenario 1	Scenario 5
Boston/Cambridge, MA	$10M	$32M
Chicago, IL	$25M	$85M
Houston, TX	$20M	$128M
Indianapolis, IN	$3M	$14M
Los Angeles, CA	$37M	$121M
New York, NY	$10M	$114M
Philadelphia, PA	$17M	$47M
San Diego, CA	$8M	$34M
Washington, DC	$6M	$35M

Estimated annual dollars saved for all commuters due to delay reductions. Scenario 1: Requirement to Offer Monthly Parking Cash-Out vs. Scenario 5: Requirement to Eliminate Subsidized Parking Benefit + Provide Universal $5 Per Day Employer-Paid Non-SOV Commute Benefit (FHWA, 2023).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The cost to implement commute benefits varies widely depending on the scale, scope, and location of the project.

Typically, commuter benefits programs are free for employees and reduce overhead for employers who can better manage parking demand from commuters. Parking facilities can carry additional costs such as maintenance, landscaping, and property taxes. However, the land value of parking has the potential to be substantial (Szambelan, 2019). Employers may be able to rent out unfilled parking spots or have reduced need to buy or rent parking space in an office building. Commuter benefits can lead to mutual cost savings for employees and employers.

Employers can choose to work with a third-party commuter benefit provider to administer commuter benefits. Administrative fees vary by vendor, number of employees, and type of services. Third-party vendors may charge fees based on a percentage of benefits received per employee, or a dollar amount per participant per month. For an example, see the NYC Department of Consumer and Worker Protection website for a list of third-party providers.

Archival Commuter Benefits Brochure (Source: APTA, 2009)

FUNDING OPPORTUNITIES

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** provides a funding source for State and local governments to fund transportation projects and programs to help meet the requirements of the Clean Air Act (CAA), including employer-based commuter choice programs designed to reduce single occupancy vehicle travel.

Qualified Transportation Fringe: Section 132(f) of the IRS Code allows for employers to offer nontaxable qualified transportation fringe (QTF) benefits. These benefits include mass transit benefits, vanpools, qualified parking and other commuter benefits.

COMPLEMENTARY STRATEGIES

Employers can create a culture that embraces active transportation by offering commuter benefits and building infrastructure that makes walking and cycling to work a safe and convenient option.

Commuter benefits can incentivize carpooling and vanpooling as viable alternative modes of transportation, benefiting both employees and employers by reducing commuting expenses while reducing GHG emissions.

Commuter benefits can complement bus rapid transit by encouraging more people to use public transit for their commute. Increased ridership on bus rapid transit systems can lead to greater efficiency and effectiveness of the service as well as potential expansion to serve more areas and accommodate growing demand.

Commuter benefits can have a positive relationship with transit expansion by encouraging more people to use public transportation. Increased demand for transit can create a stronger case for transit expansion, as transit agencies may see the need to accommodate growing numbers of riders with expanded routes, increased frequency, or new transit infrastructure.

By implementing parking reforms that make it less convenient or more expensive to drive alone to work, while simultaneously offering commuter benefits that make alternative transportation options more attractive, communities can encourage more sustainable commuting behaviors and reduce reliance on personal vehicles.

View All Strategies

CASE STUDIES

WASHINGTON STATE COMMUTE TRIP REDUCTION LAW:

Washington's State Commute Trip Reduction Law requires large employers to implement transportation demand management strategies that help to reduce congestion and emissions on the state's busiest commuting corridors. Employers' strategies are identified based on their effectiveness and their contribution to local goals around reducing vehicle miles traveled. The Washington State Department of Transportation supports the program through technical assistance, developing statewide policies and practices, and reporting on collective progress. Using strategies like these, Seattle was able to reduce the total number of drive-alone commutes by 16% and the average VMT per commuter by 23% (WSDOT, 2024; Seattle Department of Transportation, 2019).

16%

Less drive-alone commutes

23%

Reduction in average VMT per commuter

Source: King County Metro

SEATTLE, WASHINGTON:

Seattle Children's Hospital's long-running trip reduction program (established in 1995) offers valuable insights into the effectiveness of financial incentives for promoting alternative commute options. **Between 1995 and 2017, the hospital witnessed a significant decrease in SOV commute rates, dropping from 73% to 33%.**

PHILADELPHIA, PENNSYLVANIA:

Starting in 2023, Philadelphia required employers with 50+ employees to "offer an employee-paid, pre-tax payroll deduction, or provide an employer-paid direct benefit such as a public transit key card or transportation shuttle." The ordinance was signed by Mayor Jim Kenney in June 2022, and applies to employees who have worked more than 30 hours per week for the same employer in the past twelve months. According to the ordinance, employers are only required to offer the benefit if employees ask for it. Helen Gym, the council member who sponsored the ordinance, said, "By bringing new riders into our city's public transit network – this program will make our streets less congested, our air cleaner, and our city safer" (SEPTA, 2024).

Source: NJ Transit

Source: City of Philadelphia

NEW JERSEY:

NJ Governor Phil Murphy signed a commuter benefits law that went into effect on March 1st, 2020. Covering the entirety of the state, the law makes it mandatory for employers with over 20 full-time employees to offer pre-tax transit benefits. As Senator Loretta Weinberg said during the law's signing: "Commuting costs, for the most part, are a predictable expense. If you asked someone how much they spend on their commute each month, most people could give a quick estimate off the top of their head. This bill will allow workers across the state to set aside money to go towards their transportation expenses, like park-and-ride parking or transit passes, pre-tax. This would offer valuable savings to many New Jerseyans struggling to make ends meet".

IMPLEMENTING COMMUTER BENEFITS: **WHAT TO READ NEXT**

Any mention of specific companies or services within the resources linked below and elsewhere on this page is for illustrative purposes only and does not constitute an endorsement by the USDOT or federal government at large.

Federal Highway Administration, Expanding Traveler Choices through the Use of Incentives: A Compendium of Examples: This primer describes how transportation agencies and other mobility services can address recurring and non-recurring congestion through "nudges" that incorporate behavioral economic concepts and encourage travelers to choose their mode, time of travel, or route. The primer provides case studies based on programs offered by State, regional, and local transportation agencies, universities and research institutions, and within the private sector that provide incentives designed to encourage individuals to consider alternatives. In addition to reducing congestion, these incentives can lead to improvements in air quality through reduced emissions, reductions in energy consumption, safer roadways, and more livable and sustainable communities.

Best Workplaces For Commuters (BWC): BWC is an innovative membership program that provides qualifying workplaces, universities/colleges, and sites with national recognition and support. Being named a BWC is a designation that signifies each designee's dedication to providing outstanding commuter benefits, such as free or low-cost bus passes and vanpool fares, carpool programs, and comprehensive telework programs. BWC's website provides resources for potential designees, including a page that is helpful to understand federal taxes for commuters/employers.

Below are some example articles that provide information for starting a commuter benefits program:

- Edenred article: Six Steps to Starting a Commuter Benefits Program
- Indeed article: What are Commuter Benefits (And Should you Offer Them)?
- Human Interest article: Setting Up a Commuter Benefits Plan for a Small Business

RESOURCES

GENERAL RESOURCES

USDOT TRANServe Federal Transit Benefit Program: TRANServe provides federal agencies a comprehensive transit benefit solution that effectively leverages the program's experienced staff, secure online application system, benefit delivery products, and mature business processes to administer transit benefits to federal employees. TRANServe encourages federal employees to use mass transportation as the primary means of commuting from home to work and embraces the opportunity to assist federal employees with commuting practices that reduce traffic congestion and help the environment.

Section 132(f) of the IRS Code: This IRS code allows for employers to offer nontaxable qualified transportation fringe (QTF) benefits.

FHWA's An Assessment of the Expected Impacts of City-Level Parking Cash-Out and Commuter Benefits Ordinances. This FHWA effort analyzed the impact city-level parking cash-out ordinances could have on vehicle travel, congestion, greenhouse gas emissions, crashes, and equity externalities for a sample of nine cities and five distinct scenarios. The report can serve as a resource for municipalities considering enacting parking cash-out ordinances or related policies that would encourage parking cash-out.

WORKING WITH COMMUNITIES

Association for Commuter Transportation (ACT): ACT strives to create an efficient multimodal transportation system by empowering the people, places, and organizations working to advance TDM in order to improve the quality of life of commuters, enhance the livability of communities, and stimulate economic activity.

Ride Together Pierce County List of Educational Opportunities for Commute Trip Reduction Programs: The mission of Ride Together Pierce is to champion the use of sustainable transportation options amongst residents, businesses, commuters and day trippers alike in Pierce County, WA. Through a host of support services and programs that help businesses implement commuter programs and make sustainable transportation options easy for riders to access, Ride Together Pierce strives to assist the community with their traveling needs. As a result, Ride Together Pierce helps Pierce County lower carbon emissions, reduce traffic congestion and benefit from the many types of transportation services available.

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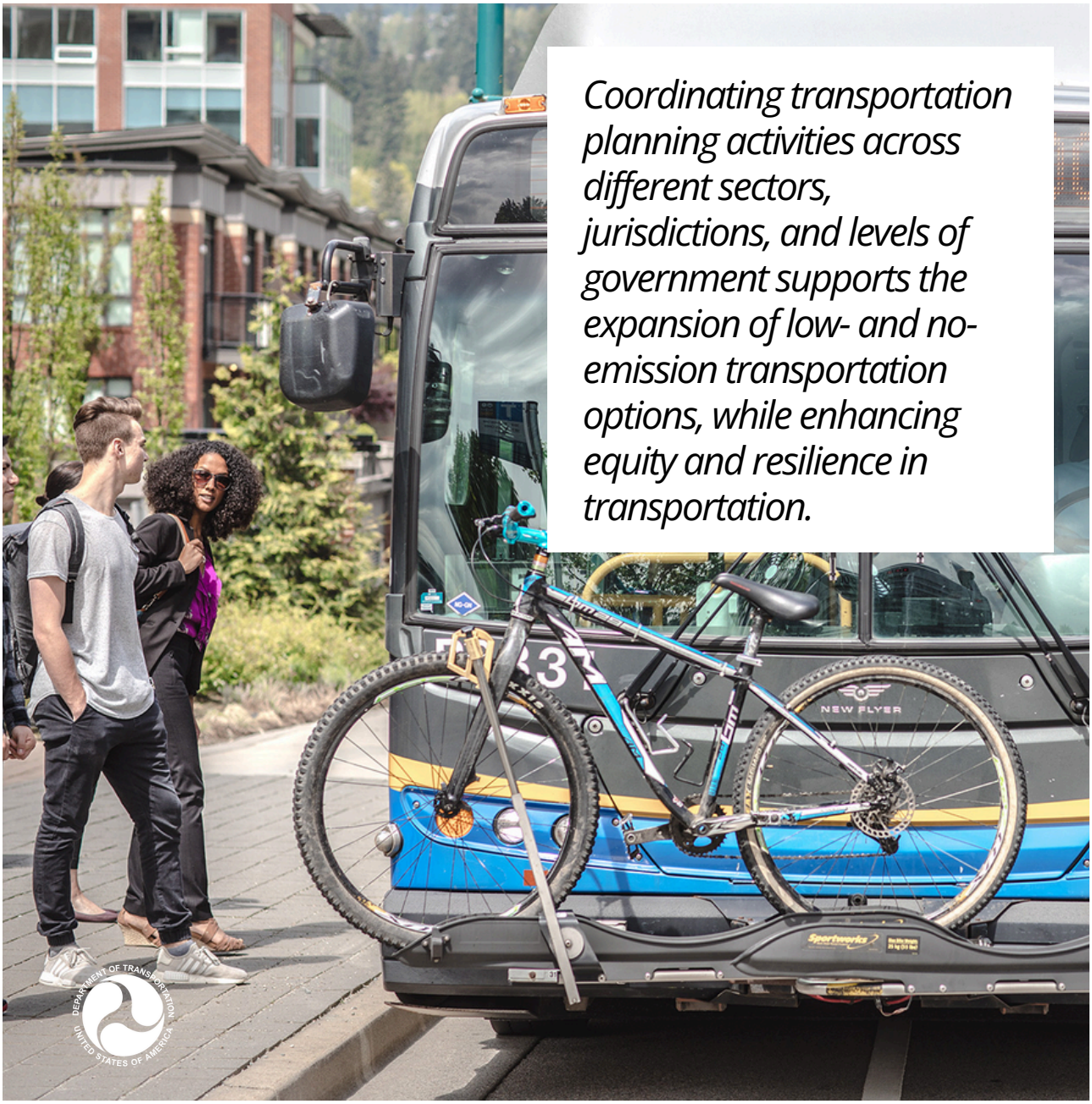
For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

COORDINATED TRANSPORTATION PLANNING



Coordinating transportation planning activities across different sectors, jurisdictions, and levels of government supports the expansion of low- and no-emission transportation options, while enhancing equity and resilience in transportation.

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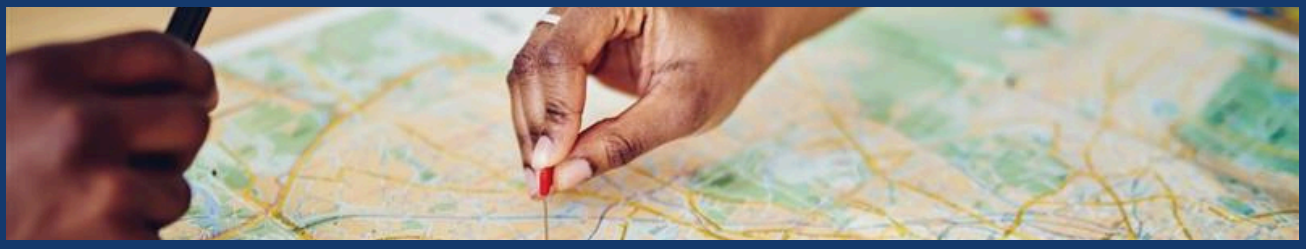
OVERVIEW

Best Suited for:
Long Term
Urban, Suburban, Rural & Tribal

Transportation planning often requires coordination across multiple sectors (i.e., transportation and housing), jurisdictions (i.e., neighboring municipalities), and levels of government (i.e., municipal, county, and state) to meet strategic goals. Transportation system development, operations, and performance depends heavily on land use, housing, the economy, environment, and public health. Transportation investments affect outcomes in these sectors as well. Thus, **coordination among transportation planners** and those doing planning in these sectors leads to **mutually beneficial outcomes** that fulfill multiple priorities, including reduction in greenhouse gases and criteria air pollutants. Many important decisions about transportation investments are made through statewide and metropolitan transportation planning processes that already cross geographic jurisdictions and multiple priority areas.

Coordinated Transportation Planning elements may include:

- Coordination between transportation and land use planning processes involves working to ensure new development complements existing transportation options and future transportation plans consider land use patterns.
- Transit-Oriented Development (TOD) reduces reliance on private vehicles through vibrant, mixed-use neighborhoods centered around high-quality public transportation. Refer to the Transit-Oriented Development strategy page for more information.
- Zoning that prioritizes affordable housing and other new development near multimodal transportation options, encourages walking, biking, and public transit, and considers parking demand management reforms. Refer to the Zoning Reform strategy page for more information.



Coordinated transportation planning brings together various stakeholders, such as government agencies, transit operators, and community groups, to develop comprehensive strategies for improving transportation systems.

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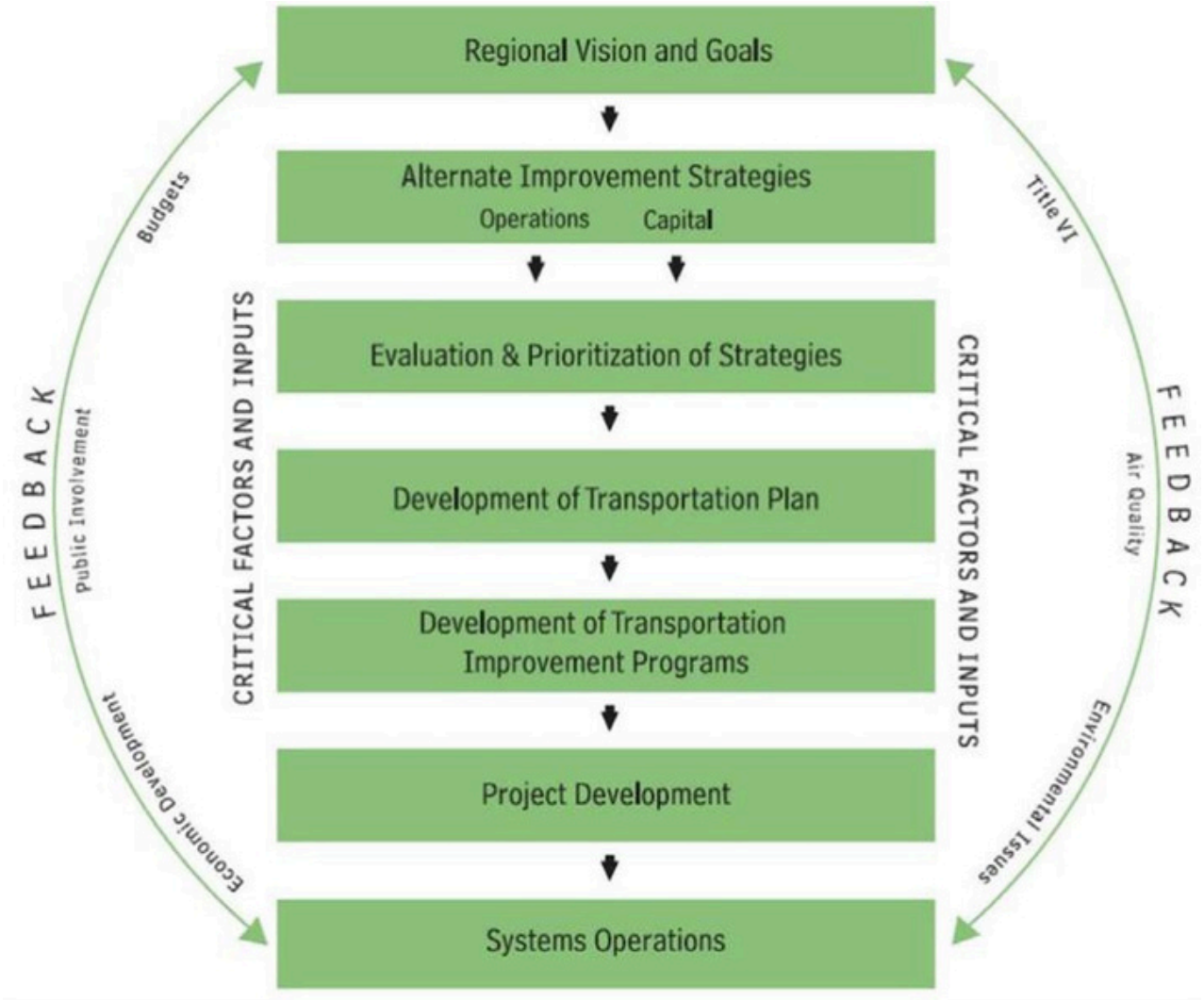


The transportation planning process (Source: FHWA, n.d.).

The Bipartisan Infrastructure Law (BIL) includes several changes in the metropolitan planning process that provide new **opportunities to align investments in transportation and housing (23 USC 134(g)(3)(A))**. This could involve projects and strategies that promote consistency between transportation improvements and state and local housing patterns as part of the transportation planning process. The law specifies a few opportunities for coordinated action:

- updating planning policy to encourage and promote the safe and efficient management, operation, and development of surface transportation systems (like roadways and streets) that will better connect housing and employment;
- consulting housing agency officials during the planning process;
- requiring the metropolitan transportation planning processes to consider projects and strategies that will promote consistency between transportation improvements and State and local housing patterns (in addition to planned growth and economic development patterns); [§ 11201(d)(3); 23 U.S.C. 134(h)(1)(E)]
- recommending assumed distribution of population and housing for consideration in optional scenarios as part of the metropolitan transportation plan; [§ 11201(d)(4)(A); 23 U.S.C. 134(i)(4)(B)]
- adding affordable housing organizations to a list of stakeholders MPOs are required to provide a reasonable opportunity to comment on the metropolitan transportation plan; [§ 11201(d)(4)(B); 23 U.S.C. 134(i)(6)(A)]
- within a metropolitan planning area that serves a transportation management area, permitting the transportation planning process to address the integration of housing, transportation, and economic development strategies through a process that provides for effective integration, including by developing a housing coordination plan. [§ 11201(d)(5); 23 U.S.C. 134(k)].

GHG REDUCTION POTENTIAL

This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

COORDINATED PLANNING AND COMPACT DEVELOPMENT

Globally, people living in more compact developments drive less VMT and produce less carbon dioxide (CO2) emissions per capita (Gim, 2020; Hong, 2017).

The IPCC estimates that integrated planning that brings about compact and efficient urban growth through co-location of residences and jobs, mixed land use, and transit-oriented development could reduce GHG emissions between 23-26% by 2050 compared to the current baseline (IPCC, 2022).

Reducing VMT through coordinated transportation planning reduces both GHG emissions and traffic congestion. In Denver, CO, redirecting growth of 8% of the city's jobs and households toward 10 regional centers reduced congestion by 6% and GHG emissions by 4% (EPA, 2007).

Nationally, compact development can reduce GHG emissions by 0.2 to 3.5% from the 2030 baseline; pedestrian improvements can reduce GHG emissions by 0.10 to 0.31% from the 2030 baseline; and bicycle improvements can reduce GHG emissions by 0.09 to 0.28% from the 2030 baseline (NASEM, 2012).

Refer to the Transit-Oriented Development strategy page for more information.

CLIMATE BENEFITS OF ZONING REFORM

A study of three high-growth U.S. metropolitan areas found that local zoning reforms to accommodate housing growth along public transportation corridors and on underutilized urban land closer to downtown would reduce VMT by up to 13% and GHG emissions by up to 14% (Holland et al., 2023).

In Albuquerque, NM, scenarios for ambitious zoning changes for more compact, infill land development were modeled to reduce transportation-related GHG emissions by about 20% from the region's 2012 baseline by the year 2040 (Tayarani et al., 2018).

Refer to the Zoning Reforms strategy page for more information.

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Coordinated transportation planning can help reduce VMT and support the development of complete streets, providing a safer environment for pedestrians and bicyclists and decreasing opportunities for vehicle-pedestrian and vehicle-bicycle crashes. Safety improvements, in turn, positively reinforce uptake of low-emission modes (Boutros et al., 2023).

Transportation planners and safety practitioners can work together to address safety challenges. See FHWA's Transportation Safety Planning website for a list of resources.

Transportation planners can support Smart Growth strategies, which encourage compact development and non-auto travel. Smart Growth has been shown to calm traffic, reducing speeds and fatality rates by 20% to 80% (Litman 2024).

ECONOMIC GROWTH

There can be economy-wide long-term cost savings associated with policies that allow more compact, mixed-use development, such as increased property values for residents and businesses, easier travel, reduced pollution, and economic stabilization of neighborhoods (EPA, n.d.).

Coordinating transportation planning that creates more compact, diverse communities can increase economic productivity, tax revenue, property values, and innovation. Multiple studies have found that economic productivity (in terms of gross domestic product, or GDP) increases with density and declines with VMT (FHWA, 2019; Ahlfeldt and Peitrostefani, 2017; Litman, 2024a).

In Des Moines, IA, a fiscal impact analysis showed that investing in a walkable urban scenario would generate a total annual net fiscal impact of $11.2 million, while a low-density scenario would only generate $7.5 million. The urban scenario would also preserve over 1,200 acres of land, which would still generate property tax revenues and potentially be used for public purposes, like parks (Smart Growth America, 2015).

ACCESSIBILITY AND EQUITY

Coordinated transportation planning expands affordable housing opportunities with convenient access to walking, biking, and riding transit. Increased access to transportation options also means more access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities (Litman, 2024a).

Transportation planning decisions can positively influence community cohesion and opportunities for people to meet and build positive relationships. Planning that improves walkability and creates more parks and public spaces for people to naturally interact can increase social interactions and reduce loneliness (Litman, 2024b; Steuteville, 2024).

RURAL COMMUNITIES

Coordinated transportation planning can benefit rural communities by allowing for more flexible land use, and supporting efforts to reduce transportation-related GHG emissions. It can enable the development of affordable housing and mixed-use areas, including creating vibrant town centers with improved walkability, bikeability, and the ability for residents to live closer to work and amenities. Overall, it can help promote sustainable growth while preserving the unique character and environment of rural areas (Litman, 2024a).

RESILIENCE AND ADAPTATION

Adaptation strategies that support community density, like preservation of open green space, using greenways or other trails to mitigate flooding or heat impacts, or using multimodal hubs as evacuation points or heating/cooling centers for vulnerable populations help communities be more resilient to extreme events like floods (Davis et al., 2023; Ciabotti et al., 2023).

AIR QUALITY AND HEALTH

Coordinated transportation planning for compact, mixed-use development that reduces the number of emissions-emitting vehicles on the road (especially in densely-populated areas) will decrease air pollutants that are harmful to human health (Litman, 2024b).

Coordinated planning can support Smart Growth and transit-oriented development, which are proven strategies to reduce vehicle travel and emissions. A literature review by Litman (2024) found that creation of multi-modal, compact communities can reduce pollution by 10% to 60%. Refer to the Transit-Oriented Development strategy page for more information.

COST SAVINGS

Shifting toward land use patterns that prioritize compact, mixed-use development easily accessible by public transit and active transportation can reduce transportation costs by reducing the need for car ownership, maintenance, fuel, and parking costs (Litman, 2024a). In 2022, transportation was the second largest household expenditure behind housing, accounting for 15% of average household spending (BTS, 2023).

COST CONSIDERATIONS

COST EFFECTIVENESS

While there may be upfront costs associated with coordinated transportation planning and implementing changes, the long-term benefits can outweigh these expenses. For example, promoting compact, mixed-use development can reduce infrastructure costs by minimizing the need for new roads, utilities and other services.

Coordinated transportation planning that encourages compact, mixed-use, transit-oriented development that is conveniently accessed by multiple modes can reduce housing costs while stimulating economic growth by attracting commercial business and visitors (NASEM, 2012; Anagol et al., 2021). This can create jobs and generate revenue for local governments. Refer to the Transit-Oriented Development strategy page for more information.

By reducing air pollution and promoting active transportation, coordinated transportation planning can improve public health and reduce health care costs associated with respiratory illnesses and traffic accidents.

COST OF IMPLEMENTATION

The cost of coordinated transportation planning can vary depending on factors such as the scope of the planning effort, the size of the community, and the extent of public engagement required. Some costs to consider include consultant and planning fees, administrative costs, and public engagement (i.e., venue rental, advertisements).

There are often opportunities to leverage funding from grants, partnerships, and other sources to support coordinated transportation planning efforts. See the Funding Opportunities section.

Transportation planning across jurisdictional boundaries is crucial to ensuring efficient, cohesive, and sustainable transportation systems.

FUNDING OPPORTUNITIES

HUD's **Pathways to Removing Obstacles to Housing (PRO Housing)** empowers communities that are actively taking steps to remove barriers to affordable housing and seeking to increase housing production and lower housing costs for families over the long term. With a specific focus on the lacking access to affordable housing which disproportionately affects people of color, this program seeks to alleviate some of the historic zoning pressures that make housing inaccessible to many.

HUD's **Community Development Block Grant (CDBG) Program** supports community development activities to build stronger and more resilient communities. To support community development, activities are identified through an ongoing process. Activities may address needs such as infrastructure, economic development projects, public facilities installation, community centers, housing rehabilitation, public services, clearance/acquisition, microenterprise assistance, code enforcement, homeowner assistance, etc.

USDOT's **Reconnecting Communities Pilot (RCP) Program** provides grants to improve multimodal transportation access, to foster equitable development, and to remove, retrofit, or mitigate highways or other transportation facilities that create barriers to community connectivity. Regional Partnerships Challenge Grants encourage stronger partnerships between local governments, Tribal governments, MPOs/RPOs, State DOTs, and non-profit, private, and community partners to tackle persistent equitable access and mobility challenges, as well as greenhouse gas emissions reductions.

FTA's **Areas of Persistent Poverty (AoPP) Program** supports increased transit access for environmental justice (EJ) populations, equity-focused community outreach and public engagement of underserved communities and adoption of equity-focused policies, reducing greenhouse gas emissions, and addressing the effects of climate change.

FTA's **increased federal share for certain planning activities** helps communities with lower population densities or lower average incomes, compared to surrounding areas, expand access to public transportation.

COMPLEMENTARY STRATEGIES

Coordinated transportation planning complements active transportation when it leads to compact, mixed-use development where destinations are convenient, accessible, and support the development and use of active transportation infrastructure. Active transportation infrastructure can help achieve coordinated transportation planning goals by making walking and biking safer, more accessible, and convenient.

When coordinated transportation planning integrates with parking reform strategies, it can encourage the use of alternative modes, such as public transit, biking, or walking, by making driving and parking less attractive.

Coordinated transportation planning helps identify where road pricing strategies could be most effective and ensures that alternative transportation options are available to commuters affected by pricing measures.

Coordinated transportation planning, complements TOD by ensuring that new developments meet a range of community needs. For example, when coordinated transportation planning for TOD involves the housing sector, it can help ensure that there is a range of housing options with convenient access to public transit.

Supporting low carbon trip planning and modal integration requires the availability of multimodal options for travelers to be able to use and plan connected trips that are not reliant on single occupancy vehicles. Coordinated transportation planning can support the vision of a network of connected transport and transit options for efficient and convenient travel by ensuring different modes are coordinated and planned effectively with lower carbon options.

Zoning codes are a key tool to implement transportation plans by determining land use patterns, densities, and the design of streets and infrastructure. When transportation planning and zoning are coordinated, zoning codes can be aligned with transportation goals to also promote TOD, pedestrian-friendly streetscapes, and mixed-use developments that reduce dependence on personal vehicles and encourage alternative modes of transportation.

View All Strategies

CASE STUDIES

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

Since the adoption of its TOD affordable housing policy in 2010, the Metropolitan Atlanta Rapid Transit Authority (MARTA) has been creative in engaging partners and fulfilling its commitment. In 2020, Invest Atlanta, the city's development authority, along with Enterprise Community Loan Fund and the Low-Income Investment Fund created a $15 million Transit-Oriented Development Fund focused on acquisition and predevelopment of affordable housing near transit. In 2021, MARTA announced the creation of a $100 million private fund to support the preservation of affordable housing within a half mile of transit stations. In 2023, MARTA secured $1.75 million in funding from the USDOT to stand up a transit and TOD accelerator, building on the strong track record of innovative solutions to funding gaps for providing affordable housing near transit.

"Phoenix Mural" by Brandon Sadler at the Five Points MARTA station (Source: MARTA).

COMMUNITY PLANNING ASSOCIATION OF SOUTHWEST IDAHO

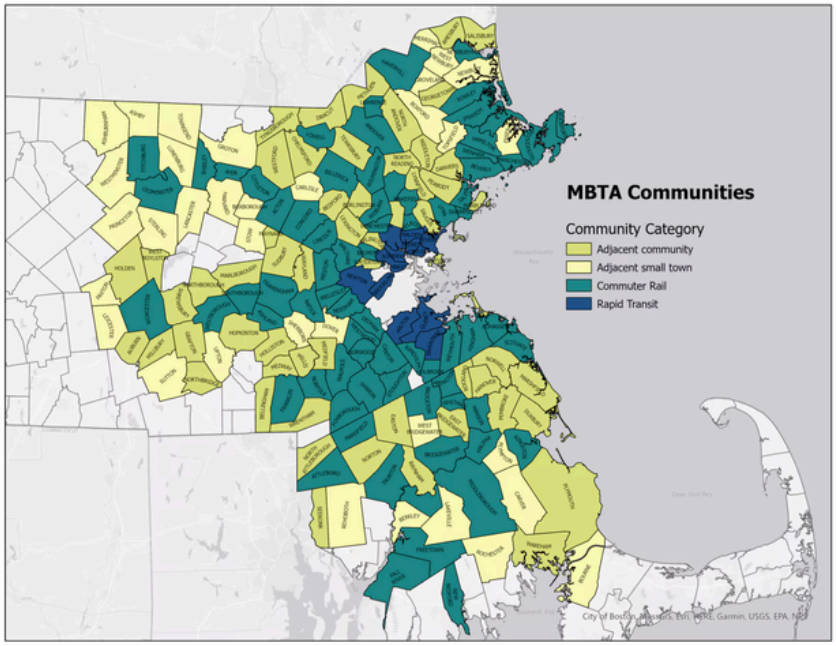
The Community Planning Association of Southwest Idaho, serving as the regional MPO for the City of Boise and greater Treasure Valley, updated its long-range plan, Communities in Motion 2050, in 2022 to include greater coordination with affordable housing development. The Community Planning Association of Southwest Idaho expanded its advisory groups to include housing representatives to inform the long-range plan, harnessing connections with United Way and others. Communities in Motion 2050 includes a vision that sites new housing near planned transit routes as well as a goal to "promote development patterns and a transportation system that provide for affordable housing and transportation options for all residents."

AGE-FRIENDLY RURAL PLANNING

In 2018, the Town of Sullivan, Maine (rural community with a population of 1,200) joined a national network of age-friendly communities that was started in the U.S. by AARP in 2021. Becoming an officially designated age-friendly community involves a comprehensive planning process resulting in policies and programs that make communities more livable so older residents remain connected and independent. Some of the strategies that Sullivan has adopted to be more age-friendly are also helping the community reduce transportation emissions, such as through better walking trails and public transportation options.

MULTI-FAMILY ZONING REQUIREMENTS IN MASSACHUSETTS

A Massachusetts law requires the Massachusetts Bay Transportation Authority (MBTA) communities, which include cities, towns, and municipalities served by MBTA services, to have at least one zoning district for multifamily housing permitted as of right. In response to the high housing and rent costs in Massachusetts, the law aims to allow multifamily housing to be close to transit stations to improve access to daily destinations and workplaces, as well as reduce reliance on single occupancy vehicles. The multifamily housing units must have a minimum gross density of 15 units per acre; located not more than half a mile from public transit stations; have no age restrictions; and be suitable for families with children.



MBTA Communities (Source: Commonwealth of Massachusetts).

IMPLEMENTING COORDINATED TRANSPORTATION PLANNING: **WHAT TO READ NEXT**

New Jersey's Transit Friendly Guide provides design guidance on orienting development around transit lines. This includes recommendations on bike and pedestrian accommodations, and design and development.

The Bipartisan Policy Center has published case studies on cities which have changed zoning regulations in order to encourage more housing development. These include changes such as eliminating parking minimums, reducing lot size requirements, and encouraging additional density. All of these changes can play into making more affordable, more walkable, and more sustainable urban environments.

The 2024 report, Community Cohesion as a Transport Planning Objective, describes the concept of community cohesion and specific planning strategies for increasing cohesion, including pedestrian improvements and inclusive design (Litman, 2024b).

See the National Center for Sustainable Transportation Research's report on best practices regarding land use and equity. The report provides an overview of tools that agencies can use to assess VMT changes, gentrification and equity impacts, and GHG impacts associated with different land use policies.

USDOT's Tools and Practices for Land Use Integration page contains examples of transportation and land use integration strategies that various jurisdictions have implemented. These include parking management approaches and transit-oriented development projects.

RESOURCES

GENERAL RESOURCES

US HUD Green Building Standards: HUD standards strongly encourage low-carbon development methods for grantees and contractors receiving funding through the Neighborhood Stabilization Program. These standards include a focus on how green housing design benefits the neighborhood fabric through proximity to transportation and access to walking and bike paths.

Federal requirements for statewide and metropolitan transportation planning: These requirements can be found under 23 U.S.C. Chapter 1, Federal-Aid Highways, and 49 U.S.C. Chapter 53, Public Transportation.

Federal Requirements for State and local Consolidated Plans: The federal requirements for state and local consolidated plans, established by HUD to serve as the planning document (comprehensive housing affordability strategy and community development plan), can be found at 24 CFR Part 91.

HUD Consolidated Planning website: This website provides an overview of the consolidated State and local planning process, introduction to HUD's Office of Community Planning and Development, and a range of resources and opportunities to keep up to date on the topic.

FHWA-FTA Transportation Planning Capacity Building website: Addressing GHG in the Transportation Planning Process: This website provides information for planners in local agencies to address GHG emissions in the planning process. The site includes information on initiatives, State and metropolitan planning organization examples, and additional resources available to learn more and stay updated on the latest developments.

FHWA Planning Processes website: This website includes tools and guidance for planning coordination at the State and metropolitan level. The site also includes information for rural, small community, and Tribal transportation planning.

APA Equity in Zoning Policy Guide: The guide provides zoning tools to position planners to lead the way on zoning for equity at the local, state, and federal level.

TOOLKITS AND MODELLING APPROACHES

National level:

EPA Motor Vehicle Emission Simulator (MOVES): The MOVES model provides vehicle emission rates and mobile-source inventories.

Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model: The model provides life-cycle emissions assessment for different vehicle technologies and futures.

Transportation Pooled Fund VisionEval Project and Associated Tools: (i.e., Energy Emissions Reduction and Policy Analysis Tool; EERPAT): These tools are designed to evaluate many alternative futures and policies to help state and metropolitan area governments address pressing issues, despite uncertainty.

FTA Transit Greenhouse Gas Emissions Estimator: The estimator is a spreadsheet-based tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operation, and maintenance phases of a project across select transit modes. Users input general information about a project, and the Estimator calculates annual GHG emissions generated in each phase.

FTA Transit Bus Fleet Electrification Tool: The Transit Bus Electrification Tool is a Microsoft Excel-based spreadsheet tool that allows users to estimate the partial lifecycle greenhouse gas emission savings associated with replacing standard bus fleets with low-emission or zero-emission transit buses.

Infrastructure Carbon Estimator (ICE): ICE is a spreadsheet tool that estimates the lifecycle energy and GHG emissions from the construction and maintenance of transportation facilities. ICE is intended to inform planning and other pre-engineering analysis such as those conducted during the NEPA process.

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

The Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

DOE Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that

can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics, for insight on the interconnected impacts between transportation and land use decisions.

DOE's Lawrence Berkely National Laboratory (LBNL) Individual Experienced Utility-Based Synthesis (INEXUS): INEXUS is a suite of accessibility metrics that measure agent-trip level accessibility. These metrics can be used to identify and measure individual travelers who benefit from improved mobility under different simulation scenarios. Tools such as these can be used to design improved operational efficiency in existing and future transportation systems.

State level:

APA Michigan Chapter Zoning Reform Toolkit: This toolkit aims to provide urban leaders with tools needed for updating and modernizing zoning and development review regulations to develop more housing types. It also includes case studies on the application of the strategies recommended. This toolkit explains elements of the affordable housing crisis and how zoning reform can act as an intervention. It also provides 15 zoning tools that can be used to address housing supply and affordability.

Massachusetts Housing Toolbox: The toolbox provides strategies and best practices, including zoning and land use tools, for the creation and preservation of affordable housing, with guides, tools and resources for local boards & committees, planners, municipal staff, developers, and volunteers.

California Quantifying the Effect of Local Government Actions on Vehicle Miles Traveled (VMT): This research resulted in a Vehicle Miles Traveled (VMT) Impact spreadsheet tool, which lets users easily see impacts for any census tract, city, or region in California.

California Emissions Estimator Model (CalEEMod): CalEEMod is a statewide land use emissions computer model designed to provide a uniform platform for government agencies, land use planners, and environmental professionals to quantify potential criteria pollutant and greenhouse gas (GHG) emissions associated with both construction and operations from a variety of land use projects.

WORKING WITH COMMUNITIES

U.S. Department of Energy's, Clean Cities Coalition Network: This network supports communities in achieving cleaner air and reducing dependence on fossil fuels by promoting alternative transportation options.

EPA's Smart Growth: This website provides resources and technical assistance to help communities integrate active transportation into their development plans, promoting compact, walkable neighborhoods.

American Planning Association (APA) Working to Address the Nation's Housing Crisis: The APA provides resources on planning-led zoning reform to address housing supply issues and explore ways planners can work with states to enable reform.

Smart Growth America: Smart Growth America empowers communities through technical assistance, advocacy and thought leadership to create livable places, healthy people, and shared prosperity. Smart Growth America also provides a variety of resources on their website to support community planning efforts and zoning reform.

Center for Neighborhood Technology: The Center for Neighborhood Technology delivers innovative analysis and solutions that support community-based organizations and local governments to create neighborhoods that are equitable, sustainable, and resilient. The Center for Neighborhood Technology provides tools and publications that support planning and zoning initiatives on their website.

RURAL SPECIFIC

FHWA Planning Processes website: This website includes tools and guidance for planning coordination at the State and metropolitan level. The site includes information for rural, small community, and Tribal transportation planning.

FTA National Rural Transit Assistance Program (RTAP): This FTA program provides technical resources, toolkits, training, webinars, a resource library, news updates, and information on Tribal transit and State RTAP programs.

AARP Livable Communities Transportation and Mobility: This website includes resources such as policy briefs and a rural transportation toolkit for rural communities on the topics of livability, funding opportunities, health care, and transportation options available in rural areas.

Community Transportation Association of America Transit Planning 4 All: This program, in partnership with several organizations, supports older adults and people with disabilities in getting involved in coordinated transportation system development. The members are involved in surveys, research activities, grants, and creating a knowledge sharing network.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

Strategic and robust charging infrastructure deployment accelerates the transition to electric mobility, promotes equitable access to clean transportation options, and fosters economic growth through innovation and job growth.

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OVERVIEW

Best Suited for:
Short Term
Urban, Suburban, Rural & Tribal

Electric vehicle (EV) charging infrastructure plays a key role in accelerating the widespread adoption of EVs. A robust charging network provides reliable and accessible charging options for EV drivers across the transportation sector – from light-duty passenger vehicles to micromobility solutions like electric bikes and scooters, as well as transit and school buses, and medium- to heavy-duty vehicles. Strategically located along highway freight corridors, curbsides, multifamily housing units, and mobility hubs, charging stations can cater to varied travel patterns and transportation system uses.

The U.S. charging network is being developed in the context of location, charging duration, and electric energy supply. Charging levels include Level 1 (120-volt or the equivalent draw of small kitchen appliances) and Level 2 (240-volt or the equivalent of a clothes dryer) for charging in homes, workplaces and public locations; and faster Level 3/ Direct Current Fast Charging (DCFC) for 480-volt charging on road trips or for fleet vehicles. As the percentage of EVs in the fleet grows, the amount and types of chargers available are also expected to grow.

To ensure widespread adoption and encourage individuals and companies to embrace electric mobility options, the charging network must be convenient, interoperable, affordable, reliable, and equitable. Planning for charging infrastructure can occur at the corridor, community, and site levels, and can also focus on specific fleets, like transit vehicles and last-mile delivery vehicles. Thoughtful planning makes EVs a more attractive option and supports choice of lower-carbon transportation.

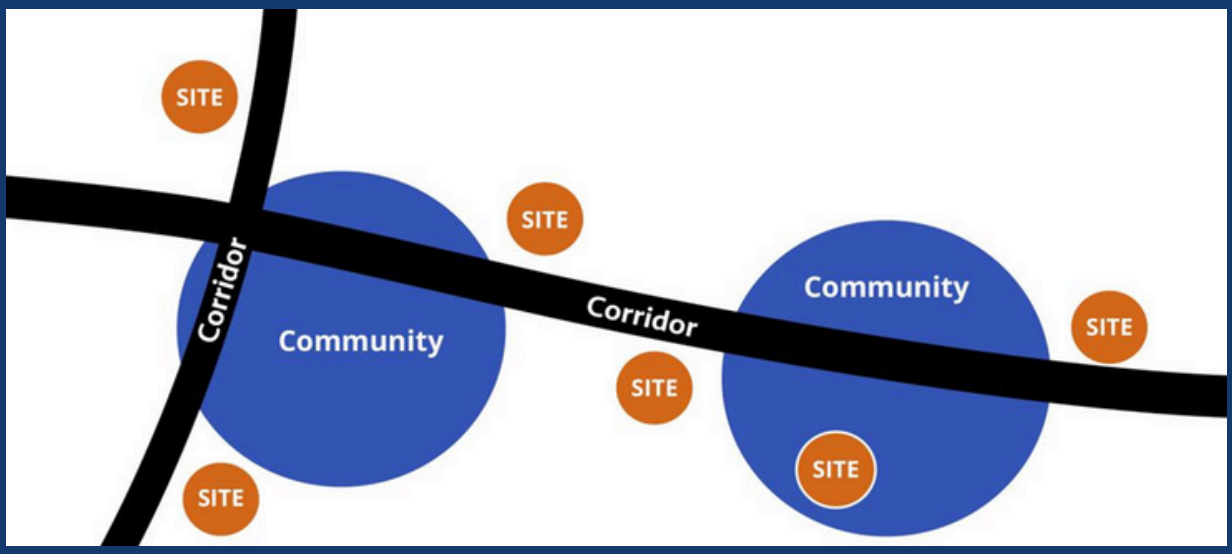
EVs have zero tailpipe emissions. Widespread adoption of EVs can greatly reduce greenhouse gas emissions and improve local air quality compared to gasoline- and diesel-powered engines. Since electricity generation can produce emissions depending on the source (natural gas, coal, wind energy, etc.), simultaneous decarbonization of the electrical grid is critical for maximizing the environmental benefits of EVs. Smart charging that accounts for peak hours and load on the grid can more effectively use renewable energy, while accounting for driver needs and electricity costs.

Charging Infrastructure Planning

As part of their E-Mobility Toolkit, USDOT provides resources for electric mobility infrastructure, including different planning approaches based on geographic scale and vehicle fleet composition. The entities best positioned to conduct each level of planning are noted in brackets.

- **Corridor-level planning** supports infrastructure along roads and highways for the needs of interregional and interstate travelers, or those "passing through" [*State DOTs, Tribal Organizations, regional planning agencies, and county governments*]
- **Community-level planning** considers infrastructure solutions to meet diverse needs within a particular region, city or neighborhood [*State, Tribal, and local governments, transportation planning agencies, transit agencies, and community organizations*]
- **Site-level planning** focuses on specific locations, including residential charging and charging infrastructure for visitors to the area [*Local leaders and stakeholders, including community- and corridor-level planners; site hosts, such as local business owners*]
- **Fleet planning** involves infrastructure planning for transit, micromobility, ride-hailing/taxi, and last-mile delivery fleets, and can occur at the corridor-, community-, or site-level [*Transit agencies, local governments, private entities, such as ride-hailing companies and delivery operators*]

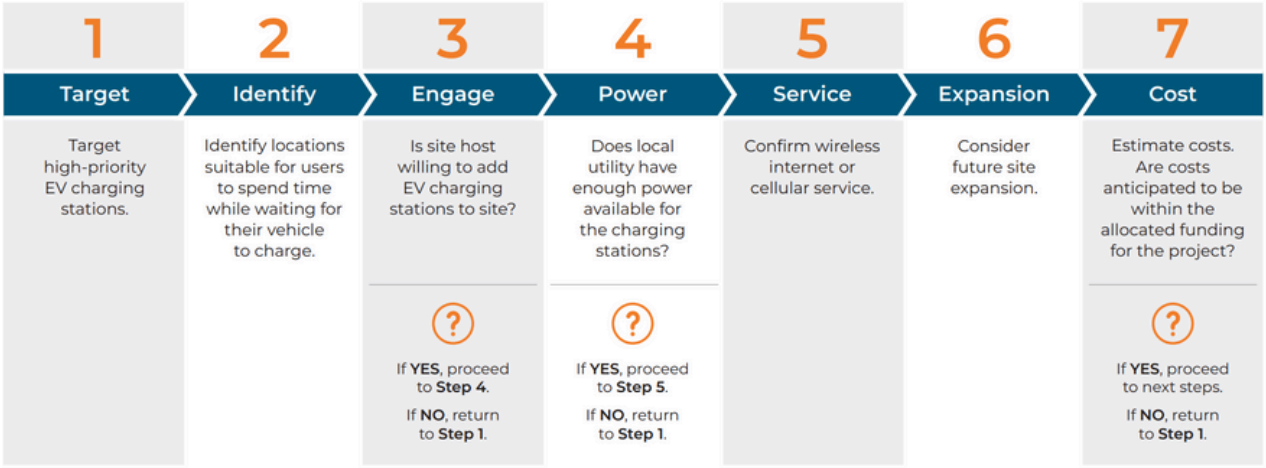
Read more here: Types of Charging Infrastructure Planning



Three levels of EV infrastructure planning: corridor, community and site (Source: Volpe Center, via USDOT, n.d.)

> On a lifecycle basis, a model year 2023 battery electric car will emit 50% the carbon dioxide equivalents over its lifetime (IEA, 2024).

Emissions from the full vehicle lifecycle are often referred to as **well-to-wheel (WTW) emissions**, covering energy and emissions associated with vehicle manufacturing, fuel production, processing, and distribution, and fuel combustion in a vehicle. In the case of an electric vehicle, WTW emissions includes emission associated with electricity production. WTW emissions can be divided into two parts: well-to-pump (WTP) and pump-to-wheel (PTW), where to pump is the gas pump with internal combustion engine vehicles (ICEV) and the charging station with electric vehicles. **On a WTW basis, EVs emit 60 g-CO_2-equivalents (eq) per mile, while ICEVs emit 35-40 g-CO_2-eq/mi** (Elgowainy et al., 2020).



There are several considerations that should be addressed when selecting a site for EV charging stations. Here are high-level steps to guide selection of publicly available charging stations (Source: Joint Office of Energy and Transportation, 2023)

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

LIFECYCLE EMISSIONS FROM EV CHARGING

Well-to-wheel emissions include all emissions related to fuel production, processing, distribution, and use. All-electric and plug-in hybrid electric vehicles have zero tailpipe emissions, but electricity production may generate emissions. As the grid utilizes more renewable sources, EVs produce fewer lifecycle emissions (Alternative Fuels Data Center, 2023).

A study from the National Renewable Energy Lab (NREL) examining a high-electrification scenario shows that transportation electricity use could grow from the current 0.2% to 23% of total U.S. electricity demand by 2050 due to widespread charging. Therefore, the full emissions reduction potential of EVs can be harnessed through a shift to renewable sources in the electrical grid energy mix (Mai et al., 2018).

One study found that an EV that charges only in Washington state generates around 70% fewer emissions during its lifecycle than the same EV only charging in West Virginia. The difference in lifecycle emissions is due to Washington's electrical grid being almost 90% less carbon intensive than West Virginia's (MIT Energy Initiative, 2019).

A study of trucks and buses in Europe found that lifecycle emissions are 63% lower for electric tractor trailers than diesel and can be as much as 84% lower with an electrical grid powered solely by renewable energy (O'Connell et al., 2023).

Micromobility Charging

Electric micromobility (e-MM) systems, like electric scooters and e-bikes, have the potential to decrease urban CO_2 emissions from the transportation sector by lowering car use. If urban trips taken by bicycles and e-bikes increase from 7% to 23%, global urban transport emissions could decrease by 7% or 300 mega tons of CO_2 (ITDP, 2015).

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EVS LOWER CARBON EMISSIONS REGARDLESS OF GRID SOURCE

EVs emit substantially less CO_2, no matter the mix of energy sources in the local grid. According to an analysis by Yale Climate Connections, the average emissions reduction in the U.S. is 66% when comparing a gasoline-powered crossover sports utility vehicle (SUV) to a similar electric SUV (Kirk, 2023).

In States with the cleanest electricity sources, driving an EV will reduce carbon emissions by around 90% compared with gasoline-fueled vehicles. In States that rely more heavily on coal for electricity generation, EVs still reduce carbon emissions by 30% or more (Kirk, 2023).

EVs have a lower carbon footprint due to their significantly higher energy efficiency compared with gasoline vehicles. EVs use approximately 90% of the energy from their battery and regenerative braking to propel the vehicle. In contrast, conventional gasoline vehicles only convert up to 25% of their energy into propulsion work (EPA, 2024).

Calculate the GHG emissions savings from electric and plug-in hybrid vehicles where you live or work:

- Alternative Fuels Data Center EV Calculator
- FuelEconomy.Gov Beyond Tailpipe Emissions Calculator

Smart Charging

Smart charging uses grid conditions to effect charging station availability and optimize energy demand from electric vehicles. One study found that utilizing this model of charging reduced emissions from energy generation by 31% (Jenn & Brown, 2021).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

COST SAVINGS

EVs require less scheduled maintenance than vehicles with gas-powered engines as maintenance and repair on elements of the engine are not necessary. While other maintenance is necessary, EVs provide cost savings in the long-run (NHTSA, n.d.).

As of February 2024, the cost of owning (buying or leasing) and operating an EV is comparable to – and sometimes less than—the cost of owning and operating an internal combustion engine vehicle (J.D. Power, 2024).

Off-peak charging at home offers cost savings due to lower energy costs during off-peak times. The cost per-kilowatt hour may be 5 to 10 times higher for public charging than home charging for consumers. Public charging often offers less flexibility for timing due to the time required away from home, so it mostly occurs during the day when energy costs are typically higher (Kampshoff et al., 2022). Greater access to charging stations, through the installation of curbside and publicly accessible chargers in residential areas, improves flexibility and reduces the burden of daytime charging (Vega-Perkins et al., 2023).

Some workplaces and businesses offer free charging as an amenity to employees or customers, offering a cost savings opportunity for EV drivers (Alternative Fuels Data Center, n.d.).

> An analysis of EV ownership in Maine, Maryland, Vermont, and Virginia found that, during the lifetime of an EV, combined savings on fuel and maintenance may range from $27,000 to $44,000 in rural areas or $22,000 to $31,000 in urban areas (Lowell et al., 2020).

AIR QUALITY AND HEALTH

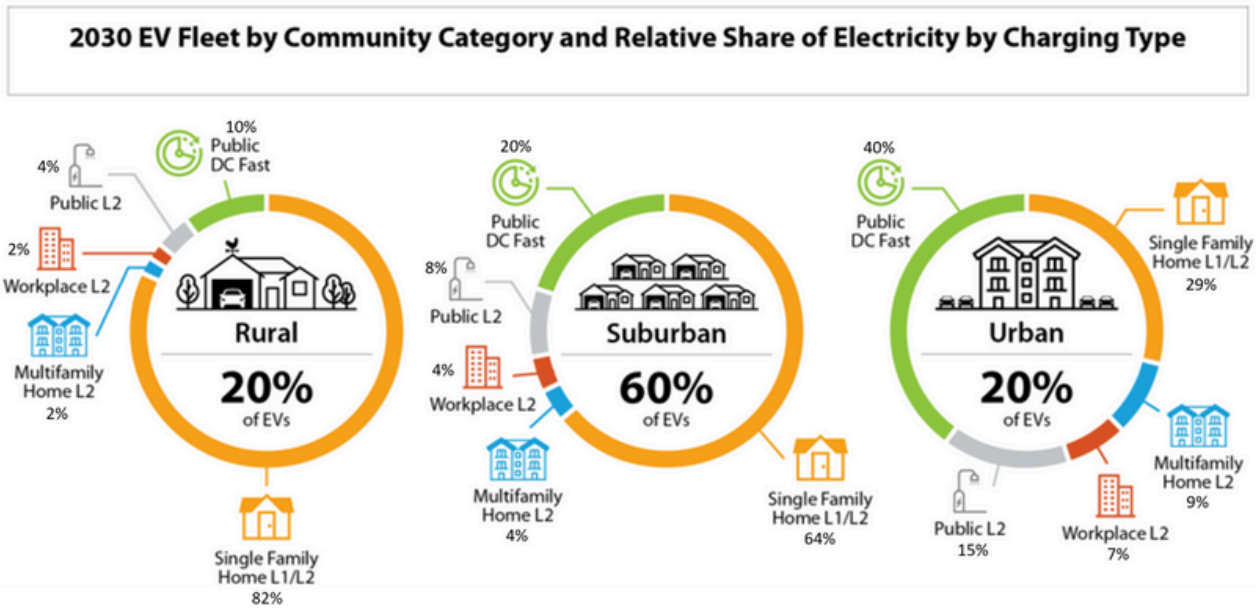
EVs produce no tailpipe emissions. Pollution from tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways (American Lung Association, 2001).

ACCESSIBILITY AND EQUITY

Tax credits and incentives offered by federal and state governments reduce the cost of purchasing an EV (Ewing, 2023). Federal tax credits of up $7,500 on new EVs and $4,000 on used EVs are offered (Oak Ridge National Laboratory, 2023). Many states also offer rebate or tax incentive programs for EVs. For example, Massachusetts offers rebates for the purchase or lease of a new or used battery electric or fuel-cell electric vehicle, and the rebate increases for low-income residents (Massachusetts Department of Energy Resources, n.d.).

Curbside and publicly installed charging stations provide access for EV drivers without access to overnight charging at home. These individuals are more likely to be from low-income households, renters, and lack access to off-street parking.

The charging network needs for EVs are different depending on whether EV owners live in rural, suburban, or urban areas. In urban areas, there are particular gaps in charging accessibility for multifamily homes. Electricity from public DC fast chargers would be most utilized in urban areas, while in rural and suburban areas, Level 1 and Level 2 chargers in single family homes are expected to meet the majority of electricity needs (Wood et al., 2023).



Source: NREL, 2023; DOE, 2024

RURAL COMMUNITIES

Rural residents drive more and spend more on gasoline and maintenance than urban drivers. EV adoption can help rural residents save money and reduce their environmental impact, given that transportation modes other than driving are often limited (USDOT, 2023).

> Rural parts of the U.S. are home to 20% of Americans and about 70% of the country's lane miles. Expanding EV charging access can save rural residents over $2,000 per year, assuming average mileage of 15,000 (USDOT, 2023).

Two forms of planning may be implemented in rural communities. Community-level planning focuses on the needs of residents or visitors of a neighborhood, town, or region for everyday charging needs and longer stops. Corridor-level planning focuses on the needs of drivers or freight operators traveling along a regional, interregional, or interstate route for a quick charge during longer trips (USDOT, 2023).

The U.S. DOT offers resources to guide rural communities on EV adoption and charger installation. For example, the following links provide additional information on the benefits of electrification for rural individuals and communities.

- Individual Benefits of Rural Vehicle Electrification
- Community Benefits of Rural Vehicle Electrification

Deploying EV chargers can attract EV drivers as an amenity to destinations in rural communities. Drivers may pair charging time with a visit to local attractions or businesses, bringing in revenue to the local community (USDOT, 2023).

ECONOMIC GROWTH

Based on projected rates of EV adoption, it has been predicted that over 150,000 new jobs will be created, ranging from certified electricians to software developers (Bui et al., 2024).

In 2021, the energy sector employed more than 7.8 million Americans, with jobs related to net-zero emissions making up about 40% of this total. Between 2020 and 2021, jobs in carbon-reducing motor vehicles and related technologies grew by 25% collectively (DOE, 2022).

RESILIENCE AND ADAPTATION

EVs can serve as a mobile power source. Bi-directional charging allows EVs to both receive energy from and discharge it to the grid as well as deliver energy to buildings. This capability is particularly useful during natural disasters (Federal Energy Management Program, n.d.).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The cost of implementation varies based on the scale and scope of the project and the type of charger installed, as shown in the table below. These costs do not include grid upgrades which may be necessary to support charging equipment.

For a charging station with six 150 kW charging ports, fixed station costs are estimated to be $103,000 and five-year maintenance costs are estimated to be $75,000 total (Chu et al., 2023).

Charger Hardware	Unit Cost per Port	Installation Cost per Port
Level 1 residential	$0[a]	$100-$1,000
Level 2 residential	$400-$1,200	$500-$1,700
Level 2 commercial	$2,200-$4,600	$2,200-$6,000
DC 50 kW	$23,000	$12,000
DC 150 kW	$69,000	$36,000
DC 250 kW	$75,500	$60,000
DC 350 kW	$82,000	$84,000
DC 500 kW	$117,143	$120,000
DC 1,000 kW	$234,286	$240,000
DC 1,500 kW	$351,429	$360,000

[a] Level 1 chargers are often included with an EV.

Cost estimates for different charger types (Source: NREL, 2023; NREL, 2024)

COST EFFECTIVENESS

Research demonstrates that constructing an EV charging network is a cost-effective strategy to support further adoption of EVs by reducing range anxiety and other limiting factors (Li et al., 2017).

Vehicle Grid Integration (VGI) reduces the need for grid upgrades by harnessing the flexibility of EVs to improve the efficiency of EVs as a piece of the grid. Therefore, VGI aims to place downward pressure on electricity rates to lower the cost of EV ownership and improve cost effectiveness. Read more about VGI here.

Implementing smart charging at EV charging stations has the potential to reduce the cost of shifting to 100% renewable energy by $30 billion in 25 years (Jenn & Brown, 2021).

FUNDING OPPORTUNITIES

FHWA has compiled other funding and financing sources for EVs and EV charging infrastructure, including what types of activities are eligible. See this FHWA resource here.

FHWA's **Charging and Fueling Infrastructure (CFI) Discretionary Grant Program** supports publicly accessible electric vehicle charging infrastructure as well as hydrogen, propane, and natural gas fueling infrastructure along designated Alternative Fuel Corridors or in other publicly accessible locations. 50 % of CFI funding must be used for a community grant program where priority is given to projects that expand access to EV charging and alternative fueling infrastructure within rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking spaces.

FHWA's **National Electric Vehicle Infrastructure Formula Program (NEVI)** provides funding to States to strategically deploy electric vehicle (EV) charging infrastructure and supports establishing an interconnected network to facilitate data collection, access, and reliability. Program funds can be used for the acquisition, installation, network connection, operation, and maintenance of EV charging stations, as well as EV charging station data sharing.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** provides a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act. Funding is available for transportation projects that reduce congestion and improve air quality such as EV charging infrastructure.

DOE's **State Energy Program** (SEP) provides annual formula funding and technical assistance to all 50 States, five territories, and the District of Columbia to enhance energy security, advance State-led energy initiatives, and increase energy affordability. States may choose to allocate funds for transportation projects, including planning and projects that promote access to EVs and buildout of EV charging infrastructure.

FHWA's **Carbon Reduction Program (CRP)** provides formula funding for states to develop carbon reduction strategies and for projects to reduce transportation carbon dioxide emissions, including traffic management, public transportation, pedestrian facilities, alternative fuels, and port electrification.

The Joint Office of Energy and Transportation maintains a list of EV and energy funding opportunities for tribal nations. Users can filter the list by project type, such as light-duty vehicle charging, micromobility, energy, and more. A selection of the opportunities is listed below, and the full list can be accessed here.

Rebuilding American Infrastructure with Sustainability and Equity: Provides a unique opportunity for the U.S. Department of Transportation to invest in road, rail, transit, and port projects that achieve national objectives. Starting in FY21, this program has substantially increased focus on zero emission vehicle infrastructure, including EV charging.

Federal Lands Access Program: Aims to improve transportation to and within Federal lands by improving transportation facilities that provide access to, are adjacent to, or are located within Federal lands.

Nationally Significant Federal Lands and Tribal Projects Program - Tribal High Priority Projects Program: Provides funding for the construction, reconstruction, and rehabilitation of nationally-significant projects within, adjacent to, or accessing Federal and tribal lands. This program provides an opportunity to address significant challenges across the nation for transportation facilities that serve Federal and tribal lands.

Rural Placemaking Innovation Challenge: Helps rural communities create plans to enhance capacity for broadband access; preserve cultural and historic structures; and support the development of transportation, housing, and recreational spaces.

COMPLEMENTARY STRATEGIES

Replacing heavy-duty diesel-powered vehicles, including school and transit buses, with EVs reduces emissions and improves air quality, providing health benefits, such as reduced asthma risk for children.

Efficiency improvements for zero emission vehicles, such as light weighting (using lighter materials to achieve better fuel efficiency and accommodate additional advanced emission control systems, safety devices, and electronic systems) can significantly reduce electricity demand. These improvements have the added benefit of reducing energy-related operational costs, which could incentivize their adoption.

By strategically locating charging stations at carshare hubs and incorporating electric vehicles into carshare fleets, municipalities can expand access to clean transportation alternatives for residents. This can be particularly useful for rural decarbonization as alternative transportation options, such as public transit, may be limited.

Zoning codes can significantly influence the availability and accessibility of electric vehicle charging infrastructure. Zoning codes can include provisions that require or incentivize the installation of electric vehicle charging stations in new developments, parking facilities, and public spaces. Zoning can also dictate the placement and design of electric vehicle charging infrastructure and can streamline the permitting process for installing the infrastructure.

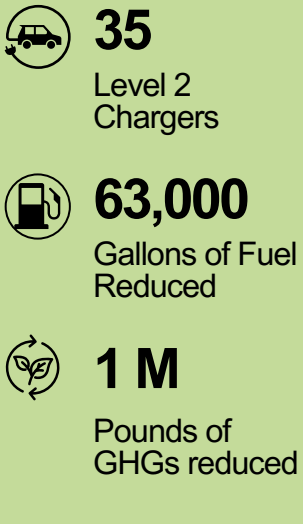
View All Strategies

CASE STUDIES

STREETLIGHT CHARGER INSTALLATION - LOS ANGELES, CA

As of February 2024, Los Angeles has installed 735 light-pole EV chargers with an estimated potential of 3,000-4,000 more based on the current light system. The installation of these chargers required minimal changes, with the director of Los Angeles; Bureau of Street Lighting noting, “At most we’ll have to changes fuses or do structural retrofits so that we can attach it.” Los Angeles is also focused on installing these chargers in underserved neighborhoods.

LEVEL 2 CHARGING STATIONS INSTALLATION AT FRITO-LAY DISTRIBUTION CENTERS



Frito-Lay installed 35 private Level 2 chargers at distribution centers in New York. These charging stations charge their 35 electric trucks overnight to allow for zero-emissions deliveries the following day. The company predicts that the electric trucks will decrease fuel use by 63,000 gallons which will reduce greenhouse gas emissions by more than 1 million pounds every year.

NEVI STATE DEPLOYMENT - HAWAII:

The National Electric Vehicle Infrastructure Program (NEVI) allocates funding to states to strategically deploy EV charging infrastructure and establish an interconnected network to facilitate data collection, access, and reliability. Under the program, states set a plan for fund use, often with a focus on disadvantaged communities and resiliency, and then provide annual progress updates. In February 2024, the first EV charging station in Hawaii funded by NEVI opened on the island of Maui. The station includes four 150-kW DC fast chargers and is located at the Kahului Park and Ride on Kuihelani Highway.

Source: Joint Office of Energy and Transportation, 2024

IMPLEMENTING ELECTRIC VEHICLE CHARGING INFRASTRUCTURE: **WHAT TO READ NEXT**

The DOE & DOT's Joint Office of Energy and Transportation provides toolkits, guidance, data, and more to support communities in deploying EV charging infrastructure.

DOT provides comprehensive guidance available on how to plan for and implement EV charging infrastructure, including the following Toolkits:

- EV Infrastructure Project Planning Checklist and Toolkit
- Charging Forward: A Toolkit for Planning and Funding Urban Electric Mobility Infrastructure

The International Energy Conservation Code recommends that infrastructure required for the installation of EV charging stations, such as sufficient energy capacity and wiring, be included in all new residential and commercial construction. Building codes that include EV-Ready provisions reduce the burden on homeowners and business owners to later install EV charging infrastructure (Thibault, 2023).

Read more about zoning for EV charging infrastructure here.

While level 2 chargers can take up to 10 hours to recharge a vehicle, Direct Current fast chargers (DCFC) reach 80% charge in 20 minutes to an hour. DCFCs are more suitable for short charges than overnight charging, suggesting they may be most useful in non-residential areas and areas with few chargers (Telang, 2021). However, DCFCs require more power, meaning that DCFC installation may be cost prohibitive in rural areas without adequate power access, including 3-phase power. Level 2 chargers are most widely used and require less power than DCFCs.

Read more about the characteristics of different chargers here.

RESOURCES

GENERAL RESOURCES

Joint Office of Energy and Transportation: The website provides access to numerous resources including a section on data and tools and provides technical assistance for states, communities, tribes, and more.

EV Charging Infrastructure Blueprint: This website includes a how-to-guide, outline of key activities, and comprehensive list of resources to help governments begin installing EV charging infrastructure.

National Electric Vehicle Infrastructure (NEVI) Program: The NEVI website includes formula program guidance, State NEVI Deployment Plans, and other EV-related resources.

Charging and Fueling Infrastructure (CFI) Discretionary Grant Program: The CFI website provides information for applicants and grant recipients.

DOE Electric Vehicle Charging Infrastructure Map: This map shows the locations of electric vehicle chargers and corridors across the United States. The results can be filtered by charger type, location, access, and fuel type.

Electric Vehicle Infrastructure Training Program (EVITP), Find A Contractor: This webpage provides a list of EVITP certified installers for each state.

Sustainable Energy Action Committee, Planning and Zoning for Electric Vehicle Deployment: This guide provides recommendations on how to navigate zoning changes for EV chargers with case text from cities across the country.

DOE Plug-In Electric Vehicle Handbook for Public Charging Station Hosts: This handbook provides guidance regarding location selection, installation, maintenance, and more for public charging station hosts.

DOE Plug-In Electric Vehicle Handbook for Fleet Managers: This handbook details how to shift a flight to electric or hybrid vehicles with specific guidance on charging infrastructure.

National Electric Vehicle Infrastructure Standards and Requirements: This final rule establishes regulations setting minimum standards and

requirements for projects funded under the NEVI Formula Program and projects for the construction of publicly accessible EV chargers under certain statutory authorities, including any EV charging infrastructure project funded with Federal funds that is treated as a project on a Federal-aid highway.

Guidebook for Deploying Zero-Emission Transit Buses: This resource provides transit agencies with information on current best practices for ZE bus deployments and lessons learned from previous deployments, industry experts, and available industry resources.

Step-by-Step Guide for School Bus Electrification: This guide identifies common steps for electrifying a school bus fleet and how to center equity in that process.

State Level

California Governor's Office of Business and Economic Development, Electric Vehicle Charging Station Permitting Guidebook: While this guidebook is aimed towards California permitting, it outlines steps to meet the electrification needs that all agencies may find useful.

TOOLKITS AND MODELING APPROACHES

Joint Office of Energy and Transportation, Public Electric Vehicle Charging Infrastructure Playbook: This interactive playbook leads readers through the process of an EV charging infrastructure project.

DOT Charging Forward: A Toolkit for Planning and Funding Urban Electric Mobility Infrastructure: This toolkit outlines strategies to successfully implement projects supporting electric mobility in urban environments, including EV charging infrastructure.

DOT EV Infrastructure Project Planning Checklist and Toolkit: The checklist provides guidance on how to plan and implement an EV project.

DOE Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite: This projection tool allows users to view the amount of charging ports needed to support the provided demand or the estimated electric load from the fleet in a given area.

FHWA and Oregon DOT, Alternative Fuel Toolkit: This toolkit provides information and additional resources to learn about, create a plan for, and implement alternative fuel strategies.

FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Emissions Calculator – Electric Vehicles and EV Charging Infrastructure: This tool estimates the emissions reduction from constructing EV charging infrastructure or purchasing an EV.

RURAL SPECIFIC

DOT Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructure: This toolkit outlines strategies to successfully implement projects supporting electric mobility in rural environments, including EV charging infrastructure.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

FREE AND REDUCED TRANSIT FARES

Free or reduced transit fares provide communities with accessible, affordable public transit options, fostering transportation equity and building inclusive communities.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Transit agencies nationwide are exploring the expansion of free- and reduced-fare programs to **bolster ridership and public transit affordability, with an eye toward reducing vehicle miles traveled (VMT).** Fare-free policies and programs represent a proactive approach to transit accessibility. Benefits of this strategy include improved operational efficiency by streamlining boarding processes, and mitigated emissions as transportation system users opt for easy-to-use public transit over high-emitting transportation modes like driving. These initiatives make public transportation more financially accessible to all residents and contribute to more inclusive and connected communities.

Did you know?

A 2021 study found 17 of the 50 largest transit agencies have low-income reduced-fare programs (Darling et al., 2021).

Partial fare-free transit provides a targeted and more limited approach to bolstering public transit access and affordability. These programs still promote accessibility, ridership growth, and operational efficiency, while maintaining some farebox revenue. At least 39 public transit agencies in the United States offer totally fare-free transit, while many more offer service that is free to certain segments of the population or in a subsection of their service area. Fare reductions are standard practice for seniors and individuals with disabilities.

The success of fare reduction strategies is **further amplified when integrated with transit-oriented development (TOD) and public transit investments**, fostering more sustainable and interconnected communities while reducing reliance on single-occupancy vehicles.

Agencies can utilize various fare plans to meet diverse community needs and optimize ridership. ***Key considerations may include:***

Targeted Demographics

- *Low-Income Riders: Programs offering discounted fares or free passes ensure affordable access for those who need it most.*
- *Children, Students, and Seniors: Reduced fares for these groups encourage ridership and promote a culture of public transportation use.*
- *Veterans and People with Disabilities: Fare reductions can ease financial burdens and create a more inclusive transportation system.*

Time-Based Fares

- *Non-Peak Periods: Lower fares during off-peak hours can incentivize ridership during less crowded times, spreading demand throughout the day.*

Mode-Based Fares

- *Low Emission Modes: Reduced fares for more sustainable transportation modes can encourage travelers to select lower emission options.*

Unique Settings

- *Low-Ridership Areas: In areas where fares contribute minimally to revenue, fare reductions can stimulate ridership and revitalize service.*
- *University Towns: Discounted fares for students can enhance student mobility and promote sustainable travel choices.*
- *Resort Towns: Free or reduced fares can improve visitor experience, alleviate traffic congestion, reduce parking demand, improve safety on roads, and remove the need to navigate unfamiliar transit payment systems.*
- *Event Management: In the context of events like concerts and sporting events, free or reduced-fare public transit can incentivize non-traditional riders to utilize public transportation, reducing traffic congestion and parking concerns around event venues.*
- *Temporary Service Disruptions: In instances where regular transit service is disrupted due to planned maintenance, unexpected breakdowns, or other operational issues, transit agencies may implement fare-free shuttle or bus replacement services to mitigate inconvenience for passengers.*
- *Emergency and Disaster Response: During emergencies such as natural disasters, severe weather events, or public safety incidents, fare-free or reduced fare transit programs play a critical role in ensuring continuity of mobility and access for affected communities.*

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

PUBLIC TRANSIT IS MORE EFFICIENT THAN OTHER MODES OF TRAVEL

A National Academies study found that passengers contributed 55% fewer GHGs per mile by riding U.S. transit in 2018 than those driving or ride hailing alone (NASEM, 2021).

Public transportation emissions averaged 0.23 kg CO_2e per passenger mile across all transit modes in 2018 including direct, indirect, and upstream GHG emissions. Meanwhile, the average Light-Duty Personal Vehicle Emissions—a weighted average of passenger cars, pickup trucks, vans, and sport utility vehicles—was 0.51 kg CO_2e per mile of direct, indirect, and upstream GHG emissions at 22.5 mpg (NASEM, 2021).

Did you know?

Even with less than 30% of its seats full, a typical bus emits a third less greenhouse gas emissions per passenger mile than the average single-occupancy U.S. vehicle (Federal Transit Administration, 2010).

DEMONSTRATED BENEFITS ACROSS THE U.S. BY TRANSIT AGENCY

Breckenridge, CO: Breckenridge, Colorado Free Ride Transit Agency, in a Livability Grant to the federal government, cited having a reduction of 202,336 pounds of CO_2 emissions in a year from choice riders using the system (NASEM, 2012).

Boston, MA: An evaluation of a Fare Free Bus Pilot in Boston estimates a total emissions reductions from a three-route pilot to reduce 1,730 annual metric tons CO_2e, cutting .03% of the city's total carbon emissions. If expanded to the rest of the Massachusetts Bay Transportation Authority (MBTA) buses, Boston would eliminate almost 2% of its total emissions (Boyle et al., 2021).

Kansas City, MO: Mid-America Regional Council's travel demand model suggests that increased ridership due to zero fare in Kansas City could result in an annual reduction of approximately 7,000 tons of carbon dioxide emissions, or 0.2% of regional transportation sector emissions (Mid-America Regional Council, 2022).

California: A study by the California Air Pollution Control Officers Association (CAPCOA) estimates that reduced transit fare programs can reduce GHG emissions by 1.2% (CAPCOA, 2021).

How was this calculated? The quantification looks at the San Jose-Sunnyvale-Santa Clara area, where transit and vehicle mode shares are 6.69% and 91.32%, respectively. Assuming the maximum decrease in transit fares is 50% and implementation is across all transit routes (100%) in the plan/community, the user would reduce plan/community GHG emissions from vehicles miles traveled (VMT) by 0.6% (CAPCOA, 2021).

FREE AND REDUCED TRANSIT FARES LEADS TO VMT REDUCTION

Studies conducted in Montgomery County, MD, explored the impact of various fare-reduction policies on VMT, including free fares and 50% fare reduction. The analysis revealed that free fares for all riders resulted in the most significant reduction in VMT. Free fares led to an estimated decrease of around 7 vehicle miles per resident annually – roughly equivalent to a single local shopping or personal errand trip.

> Interestingly, the study also found that means-tested discounts, while beneficial, had a smaller impact on VMT reduction compared to broader fare reductions. This suggests that fare reductions can incentivize not only low-income riders, who may already rely on public transit, but also higher-income residents who might be considering alternative transportation options for shorter trips (Montgomery County DOT, 2021).

Colorado's Regional Air Quality Council (RAQC) estimates that the Zero Fare for Better Air (ZFBA) campaign for the Denver transit system led to a 12% increase in ridership. This increase in transit use translates to daily reductions of nearly 150,000 VMT, 42 pounds of volatile organic compounds, 38 pounds of nitrogen oxides, and approximately 100,000 pounds of GHGs (Regional Transportation District Denver, 2023).

The Sacramento Council of Governments modeled the impacts of a Free Transit Fare Policy on travel patterns and found that free transit fares would lead to decreases in daily VMT of 0.2% and vehicle hours of delay of 0.4%, and an increase transit ridership of 30.6% (Fehr & Peers, n.d.).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

There is evidence that zero fare programs, particularly those implemented during the COVID-19 pandemic, improved security on transit systems. On RideKC in Kansas City, MO, security incidents dropped by more than 39% from 2019 to 2020 and incidents per 100,000 riders declined by about 17% (Mid-America Regional Council, 2022).

Free and reduced fares encourage more travelers to choose public transit over cars. Passenger transportation by transit is significantly safer than transportation on highways. In 2021, there were 197 fatalities reported on transit in the country, compared to nearly 42,939 highway deaths (BTS, 2021).

Eliminating fares can reduce fare disputes between operators and passengers, allowing them to focus on safe and efficient travel (SUMC, 2022).

ACCESSIBILITY AND EQUITY

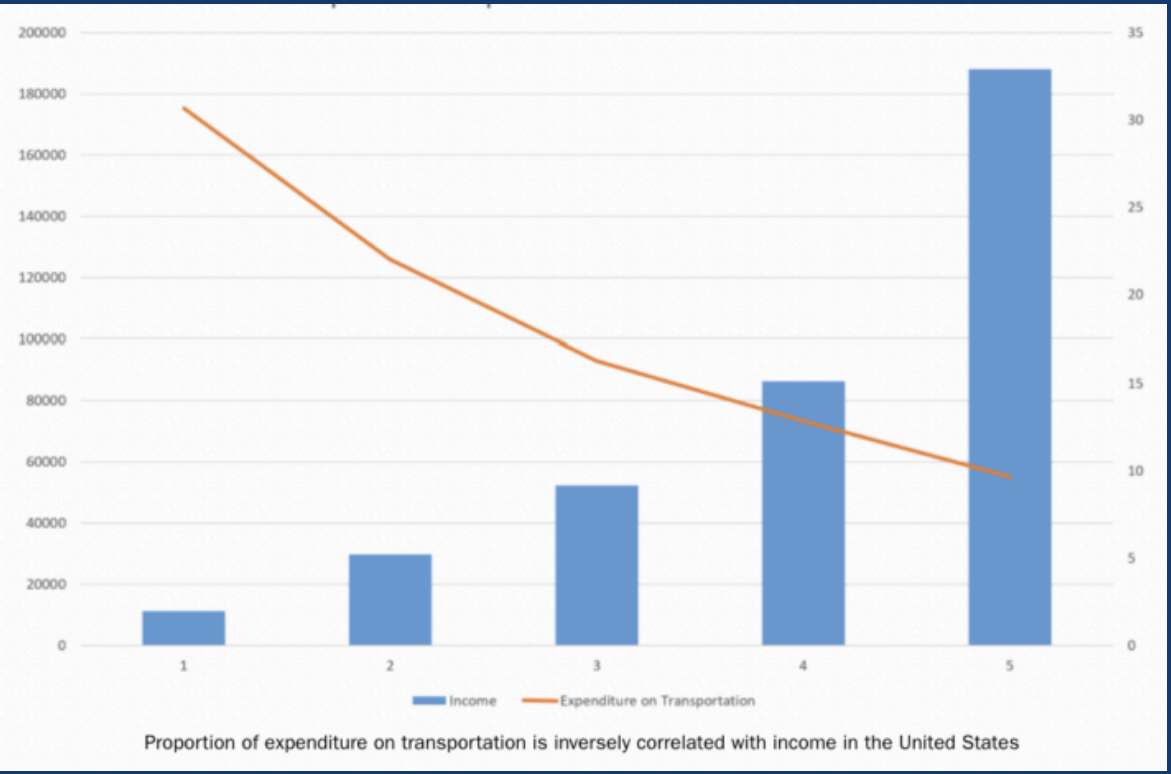
Persistent barriers to opportunity have disproportionately impacted communities of color, limiting their access to essential services, employment opportunities, and cultural amenities. Fares represent a significant financial barrier for low-income riders, further exacerbating disparities in mobility access. By minimizing this financial burden through reduced or zero fares, transit agencies can help alleviate the transportation-related hardships faced by marginalized communities. This not only enhances their ability to access critical resources and employment opportunities but also fosters greater equity across the transportation network (Darling et al., 2021).

Free and reduced transit fares increase access to essential services. A study conducted as part of the Urban League of Greater Kansas City's annual "State of Black Kansas City" report in 2022 asked 1,686 riders for their feedback on what Zero Fare has enabled them to do.

About 92% said it allowed them to shop for food more often; 88% said they could see their healthcare providers more easily or more often; 82% said it allowed them to get or keep a job; and 86% said it made them feel like city leadership is concerned about their needs (Smith, 2022).

The proportion of US household expenditures spent on transportation is inversely correlated with rising income brackets, due in part to the unequal costs and burdens of car ownership (ITDP, 2024).

Portion of Transportation Expenditure relative to Income: United States (Source: ITDP, 2024)



ECONOMIC GROWTH

Transit use supports economic development by shifting consumer spending. The money saved by low-income transit riders through fare-free or reduced fare programs can circulate through the economy, stimulating local businesses and services (Litman, 2024).

Although removing or reducing fares reduces revenue from fare collection, it may also attract new ridership and stimulate economic activity along transit corridors, potentially offsetting revenue losses through increased sales tax revenue and other economic benefits.

> For example, the annual economic impact of continuing a zero fare program in Kansas City was estimated in terms of employment and economic output – the program would raise regional employment two-fold, increase economic output by $4.2 million, and increase personal income in surrounding communities by $1.3 million (Mid-America Regional Council, 2022).

AIR QUALITY AND HEALTH

Reduced fare encourages transit ridership, potentially reducing dependence on single occupancy vehicles. Reducing the number of emissions-emitting vehicles on the road (especially in densely-populated areas) will decrease air pollutants that are harmful to human health (Litman, 2024).

Reduced or free transit facilitates better access to health care. Interviews conducted throughout a MIT evaluation of low-income transit riders in Boston suggests when transit cost is an issue, individuals are more likely to forgo healthcare trips for chronic conditions compared to acute illnesses or emergencies (Rosenblum et al., 2019).

Reduced or free transit facilitates better access to healthy food. In surveys conducted by U.S. Hunger, 42.6% of individuals reported that they do not have access to transportation to go to grocery stores that provide fresh and healthy food options (U.S. Hunger, 2022).

> With funding from the National Institutes of Health (NIH) and Environmental Protection Agency (EPA), the University of Missouri-Kansas and Children's Mercy Hospital, are researching if free-fare buses help people get more physical activity, better access to health care, and sources of healthy food.
> *Read more, here.*

COST CONSIDERATIONS

COST EFFECTIVENESS

Administrative Cost Savings: By removing fare collection processes, such as ticketing and fare enforcement, smaller transit systems can reduce overhead costs and allocate resources more efficiently to other areas of service provision and maintenance.

> *There may be a more viable argument for removing fares in cities where fares make up smaller percentages of transit operating budgets.* In the case of Kansas City, before introducing free transit, fares in 2011 to 2014 made up only 7 to 12% of the buses' operating budget, or an average of $12 million annually. Meanwhile, fare collection was costing the city $2 to $3 million annually (Picciotto, 2023). In New York City, fares make up a much larger 23% of the transit agency's operating budget (Metropolitan Transit Agency, n.d.).

Operating Efficiency: Eliminating fares streamlines boarding processes and therefore reduces dwell times at stops. This efficiency leads to timelier departures, which can improve service punctuality and frequency.

> A study by the National Association of City Transportation Officials (NACTO), found that on busy routes the time spent waiting for passengers to board and depart the bus, known as "dwell time", can be as much as one-third of bus travel time (NACTO, 2017).

> Results from a fare free pilot in 2023 in the City of Lawrence, Kansas demonstrate that on-time performance increased by 8% overall across 12 City and Coordinated routes (Lawrence Transit, 2023).

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

FTA's **Accelerating Innovative Mobility Grants** provide funding to support the development, testing, and implementation of innovative technologies, practices, and service models that improve public transportation.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** funds may be used with conditions to support innovative fare policies and financial incentive strategies designed to encourage transit use and reduce exceedances of air quality standards. CMAQ funds may be used to offer reduced fares or free transit or vanpool services when these subsidies are part of an area-wide strategy for reducing emissions during peak periods of ozone pollution.

USDOT's **Reconnecting Communities and Neighborhoods (RCN) Program** provides grants to improve multimodal transportation access, to foster equitable development, and to remove, retrofit, or mitigate highways or other transportation facilities that create barriers to community connectivity. Projects that improve walkability, safety, and affordable transportation access are eligible for funding.

USDOT's **Flexible Funding for Transit and Transit Access** program reduces emissions through transit investment. Transferring, or flexing, funds from Federal Highway programs to the Federal Transit program facilitates federal investments at the local level for measures that improve access, particularly for underserved groups.

COMPLEMENTARY STRATEGIES

TRANSIT-ORIENTED DEVELOPMENT (TOD)

Free and reduced transit fare strategies further incentivize people to use public transportation, increasing ridership and supporting the viability of TOD. Free and reduced transit fare strategies can also help mitigate transportation costs, making it more attractive to live in TOD areas and reduce barriers to accessing employment, education, and essential services. TOD and free and reduced transit fare strategies work together to promote equitable access to transportation while reducing GHG emissions.

TRANSIT SYSTEM INTEGRATION

Integrated transit networks can help maximize the impact of free or reduced fare programs by ensuring that subsidized transit services are well-connected and easily accessible to the communities they serve. Conversely, offering free or reduced fare transit passes can encourage more people to use public transportation, thereby increasing demand for integrated transit services and further justifying investments in transit integration initiatives.

PARKING REFORMS

Free or reduced fare transit programs incentivize transit use, thereby reducing demand for parking. Parking reform initiatives incentivize commuters to explore other transportation options, including utilizing free or reduced fare transit services.

View All Strategies

CASE STUDIES

SAN MATEO SAMTRANS' MEANS-BASED FARE PILOT

Source: SamTrans

SamTrans joined the Regional Means-Based Fare Pilot Program (Clipper START Pilot Program), administered by the Metropolitan Transportation Commission, in January 2021 and will continue through June 2023. This initiative targets adults aged 19 through 64, residing in any of the nine San Francisco Bay Area counties, with an annual household income at or below 200% of the Federal Poverty Level. Participants, upon acceptance and enrollment, enjoy a 50% fare discount on adult single rides. Additionally, the program introduces the SamTrans Youth Unlimited Pass, offering free rides for six months to eligible students. The student program targets users that previously didn't use public transportation; There are existing unlimited bus fares for Socioeconomically Disadvantaged (SED) students.

Source: Federal Transit Administration

UTAH TRANSIT AUTHORITY (UTA) FARE FREE FEBRUARY

UTA's Fare Free February initiative in 2022, offering fare waivers throughout the month, led to substantial increases in ridership, particularly among the 47% identified as "choice" riders with access to private vehicles. Weekday ridership saw a commendable uptick of 16.2%, while weekends witnessed more pronounced spikes at 58.1% and 32.5%. Intriguingly, over one-fifth of participants were new riders. The program's emphasis on equity benefits aligns strategically with broader goals of improving cost efficiency, enhancing quality of life, and fostering accessibility. Post-program, UTA implemented the Reduce Fare FAREPAY Card, providing a 50% discount off the public fare to all qualifying seniors, youth, persons with disabilities, and individuals who qualify based on income. This initiative further contributes to the promotion of inclusive and accessible public transportation.

RIDE ON MONTGOMERY COUNTY, REDUCED OR FREE FARE STUDY

In response to the pandemic and public health concerns, Ride On in Montgomery County implemented a back-door policy, effectively discontinuing fare collection. A back-door policy allows passengers to enter and exit the bus through the rear doors, bypassing the fare collection point typically located at the front doors. As of this writing, the program has since remained in effect. Ride On serves individuals with an estimated median customer income around $35,000, notably lower than the county's $108,000 median income. About two-thirds of Ride On customers lack access to an automobile, and most riders come from households struggling to cover basic needs.

Source: Montgomery County

Source: Autoridad de Transporte Integrado

PUERTO RICO

Hurricane Irma and María significantly impacted public transit ridership in Puerto Rico. While in 2016, the system boasted nearly 7.9 million users, 2023 ridership hovered below 3, with 2.7 million users. To reactivate ridership, the Puerto Rico Integrated Transportation Authority (ATI) implemented a free fare program during the rollout of a new ticketing and access systems. The initiative began in March 2024 and was slated for six months. The free fares applied across the entire island, encompassing all routes serviced by:

- The Urban Train (Tren Urbano or TU)
- The Metropolitan Bus Authority (Autoridad Metropolitana de Autobuses, or AMA) buses
- Metro Urbano (bus rapid transit operating between the municipalities of Toa Baja and Bayamón and from Caguas to Cupey)
- Metrobús (fixed route linking San Juan with Río Piedras)
- 'Your Connection", or 'Tu Conexión' (bus service connecting suburban residents to centers in San Juan and Old San Juan)

During the first week of free service, ridership grew by 26%, exceeding 53,200 passengers.

IMPLEMENTING FREE AND REDUCED TRANSIT: **WHAT TO READ NEXT**

Tailored Approach

There is no single, optimal approach to free or reduced fares. The most effective program design will depend on a specific region's unique needs and desired outcomes.

> Ealuating existing programs in other cities offers valuable insights.
> Consider: Ride On Zero & Reduced Fare Study, Montogomery County DOT
> The Implications of a Fare-Free WRTA, Worster Regional Research Bureau, Inc
> The Road To Transit Equity: The Case for Universal Fareless Transit in Los Angeles

Scaling Up Effectively

High ridership stemming from fare reductions is a positive outcome, but it necessitates proactive planning. Transit agencies must strategically allocate resources to accommodate increased demand. This may involve:

- Optimizing Service: Analyzing ridership patterns to adjust routes and schedules as needed.
- Enhancing Capacity: Investing in additional vehicles and infrastructure to manage ridership growth.
- Strengthening Maintenance: Ensuring existing and new vehicles are properly maintained to ensure service reliability.

Funding Strategies

Implementing fare-free systems may necessitate exploring alternative revenue models, such as increased local and state government support, public-private partnerships, or innovative funding mechanisms.

Davis County, Utah, leverages local businesses to fund its free trolley bus. Read more here.

In Philadelphia, nearly two dozen institutions have partnered with the Southeastern Pennsylvania Transportation Authority (SEPTA) to provide free transit to their employees. Among the institutions, include the City of Philadelphia, Penn Medicine, Drexel University and Wawa convenience stores. Read more here.

Phased Implementation

Often, a pilot program with a limited scope is a prudent first step. Piloting fare reductions on specific routes or for targeted demographics allows for:

- Data Collection: Gathering data on ridership changes, cost impacts, and social equity benefits.
- Program Evaluation: Assessing the program's effectiveness and identifying areas for improvement before full-scale implementation.

Read about Boston's Free Bus Fare Pilot on three select routes here.

Source: Institute for Transportation Development Policy

Partnerships for a Seamless Experience, Success Story

Kansas City Area Transportation Authority (KCATA) has leveraged partnerships with local shelters and advocacy organizations to proactively address onboard disruptions. In combination with requiring individuals to get off the bus after each route cycle, case management teams are put on the agency's vehicles to offer resources and ensure unhoused individuals are effectively supported (Shared-Use Mobility Center, 2022).

Read more here.

RESOURCES

GENERAL RESOURCES

FTA Reduced Fares for Seniors, People with Disabilities, and Medicare Cardholders Policy: Under 49 U.S.C. Section 5307, federally subsidized transit providers may not charge more than half of the peak fare for fixed route transit during off-peak hours for seniors, people with disabilities, and Medicare cardholders. This policy increases access to transit for these major swaths of the population, while also assisting some of the people who are most likely to benefit from reduced financial burden to use transit.

Shared-Use Mobility Center MLC, Zero-Fare Transit: This resource compiles key takeaways from the Mobility Innovation Collaborative on the benefits and considerations of zero-fare transit programs.

FRAMEWORKS

Fare-Free Transit Policies and Programs —An Evaluation Framework: This Transportation Research Board webinar offers a framework for evaluating the effectiveness of fare-free transit policies and programs.

Transit Center, A Fare Framework: How Transit Agencies Can Set Fare Policy Based on Strategic Goals: this report details three different cities fair policies and the strategic goals considered, including factors like revenue generation, ridership, ease of payment, and fare discounts for low-income riders.

Comparison of Reduced-Fare Programs for Low-Income Transit Riders: This journal article analyzes existing low-income fare programs in major transit agencies, comparing them to identify common practices and develop a method to assess the "fare burden" for program participants.

LOCAL STUDIES AND EVALUATIONS

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The Implications of a Fare-Free WRTA, Worster Regional Research Bureau, Inc. (2019): This research by the Worcester Regional Research Bureau investigates the potential social, economic, and operational consequences of implementing a fare-free system

on the Worcester Regional Transit Authority.

The Road To Transit Equity: The Case for Universal Fareless Transit in Los Angeles: This report by Strategic Actions for a Just Economy (SAJE) examines the case for universal fare-free transit in Los Angeles, exploring potential benefits like ridership increases, reduced emissions, and improved access for low-income residents.

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U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

FREIGHT DIGITAL SOLUTIONS AND EMERGING TECHNOLOGIES

Digital solutions and innovative technologies provide a seamless experience for freight carriers and consumers alike while reducing traffic and emissions associated with deliveries.

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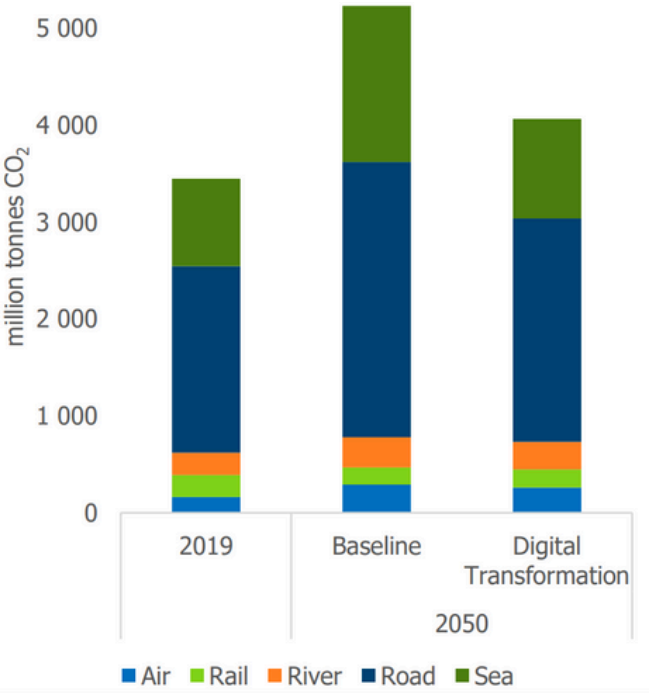
OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Freight digitalization can provide environmental, health, and economic benefits, including **reduced congestion on roadways and in and around ports, lower emissions, and operational and efficiency improvements** for freight carriers (see the Freight Operational Strategies strategy page for more detail). Digital solutions include advanced scheduling and routing systems, location tracking using geographic information systems (GIS), and other intelligent transportation systems (ITS) (see the Intelligent Transportation Systems strategy page for more detail). The International Transport Forum analyzed the overall impacts of a 'Digital Transformation' scenario on freight-related CO_2 emissions and found that implementing a range of digital solutions to the freight sector will result in over 20% lower CO_2 emissions in 2050 compared to the no-action baseline.



The impact of digital transformation on freight-related CO_2 emissions. The total rise in emissions between 2019 and 2050 is limited to only 18%, despite the expected 165% increase in freight transport demand. (Source: ITF, 2022)

Freight industry leaders have strong incentives to reduce unnecessary travel, delays, and other factors that contribute to higher operating costs. **Innovative technologies,** such as truck platooning technology or other connected vehicle technologies, **can improve the efficiency of transportation assets and services, including freight logistics.**

Did you know?

The National Renewable Energy Lab (NREL) has partnered with Google to reduce emissions through more eco-friendly mapping in Google maps. Eco-routing solutions have been shown to reduce fuel consumption and emissions by 10-20% or more (NREL, 2021).

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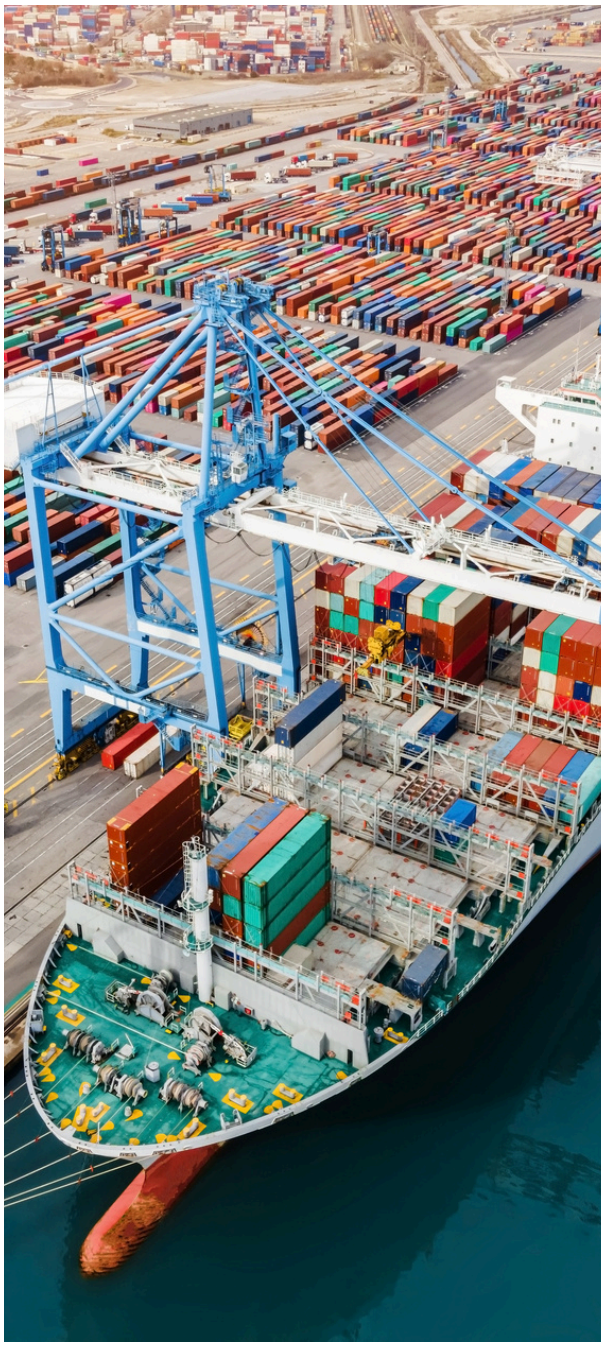
Real-time data can allow transportation systems to operate more efficiently and respond to changes and unexpected delays more effectively. For example, optimizing truck deliveries to ports through improved scheduling, automated gate systems, and other strategies can reduce emissions from trucks idling while waiting to unload their cargo. Micromobility devices such as electric cargo bikes have increasingly become integrated into goods movement and are typically managed using apps and location-based services. Truck signal priority can be used at intersections with high levels of truck traffic to extend the green time and allow more trucks to make it through a signal cycle. Giving trucks extra green time can improve safety by reducing the likelihood that a truck will run a red light and cause a crash. It can also reduce delays and congestion caused by the longer acceleration times that trucks need to reach posted speed limits.

Curb Management:
Managing the curb is an increasingly important task that can contribute to VMT reductions from freight in both urban and downtown rural core contexts. Curb management options, such as parking spot reservation systems and off-peak deliveries, can be implemented using phone apps and GIS location tracking. Delivery lockers can also reduce curb congestion and respond to an increase in demand for deliveries. Firms can use delivery lockers to consolidate shipments for multiple households, reducing delivery costs and trips. At the same time, customers can pick up their package at their convenience at a secure location close to their home. Both companies and consumers can manage delivery lockers using apps and automated systems.



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Examples of freight digitalization technologies include:

- Apps that freight carriers, businesses, and consumers can use to manage goods movement and deliveries.
- Advanced truck routing systems (dynamic re-routing or eco-routing).
- Electronic delivery lockers.
- Micromobility deliveries, including e-cargo bikes and robots.
- Drone deliveries.
- Ports technologies.
  - Multi-modal scheduling systems.
  - Truck appointment systems.
  - Just-in-time queuing.
  - Automatic gates.
- Vehicle-to-everything (V2X) deployments for freight.
  - Connected vehicle technologies.
    - V2X-enabled vehicles using dedicated 5.9 GHz spectrum.
  - Signalized intersections.

GHG REDUCTION POTENTIAL

This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

VEHICLE-TO-EVERYTHING (V2X) TECHNOLOGIES AND FREIGHT-RELATED EMISSIONS

Frequent acceleration/deceleration, excessive speeds, slow movements on congested roads, and unnecessary idling contribute to increased fuel consumption and emissions.

Eco-driving strategies, early warning systems, and other **vehicle-to-vehicle and vehicle-to-infrastructure technologies (V2V/V2I) systems** can reduce CO_2 emissions. For example, hazard alert systems installed in trucks and passenger cars can reduce CO_2 emissions by around 5% for vehicular densities up to 3000 vehicles/hour (Outay et al., 2019).

Advanced truck routing systems can reduce VMT and emissions. In one study with a medium-sized logistics company, application of an advanced scheduling and routing system to urban deliveries resulted in a 27% reduction in CO_2 emissions and the same number of orders being delivered with 8.6% less routes, 18% less service time, and 21% less kilometers per route (Kechagias et al., 2020).

The **Pittsburgh Smart Loading Zones program** uses a combination of technology to monitor loading zone utilization and notify the parking authority of violations. Pilot program outcomes include substantial reductions in idling time and curb disruptions: decrease in average park duration of 25%, decrease in average double park duration of 40%, and increase in turnover of nearly 25% (Engage Pittsburgh, 2024).

The North Central Texas Council of Governments is working with Freightpriority to deploy **signal prioritization technology** in the Dallas-Fort Worth area. The truck signal priority system uses existing GPS data to provide extra green time as needed at specific intersections. The deployment is expected to improve route efficiency and reduce fuel use and freight truck-related emissions across the region (Freightpriority, 2024).

REDUCING EMPTY TRUCK TRIPS AND IMPROVING LOAD FACTOR

"Full Truckload" (FTL) and "Less-than-Truckload" (LTL) are types of trucking services. FTL is popular with business that move large volumes of stock on a regular basis. One shipping trailer contracts to a single shipper, consignee or customer. The freight shipment (which may or may not utilize the entire trailer) is carried from point A to point B. In LTL shipping, the carrier makes multiple stops to pick up and drop off goods, and the shipment may be loaded and unloaded multiple times. LTL is better suited for occasional, smaller shipments where delivery times can be flexible.

Typical trucks that are not driving empty carry only about 57% of their capacity. “Digital freight brokers” can help consolidate loads from multiple shippers onto a single trailer to improve the loader factor. Pooling shipments can reduce GHG emissions by 15-40% (Nakajima, 2024).

Flock Freight has developed an alternative to LTL called “shared truckloads” (STL). Their technology estimates shipment pricing based on the probability that the shipments can be pooled and creates a shipment plan for a single truck that enables pooling when possible. Flock estimates that their STL solution reduces GHG emissions by 15-40% due to more direct routing and improved load factors (Nakajima, 2024).

Empty truck trips are responsible for a significant share of VMT and emissions. Collaboration among carriers and truck appointment systems (TASs) can help reduce the number of trips between terminals and client locations (Schulte et al., 2017).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Digitalization of freight movements can improve safety outcomes, including decreasing interactions between freight vehicles and vulnerable road users. See the safety benefits of recent ITS deployments here.

- Trucks can be retrofitted with bicyclist/pedestrian detection systems and collision early-warning systems.
- Signal priority for freight vehicles at intersections can reduce frequent accelerations and decelerations and reduce the likelihood of accidents.
- Smart loading zones and curb management systems reduce congestion from delivery vehicles and the need for double parking and parking across bike lanes.

See the Intelligent Transportation Systems strategy page for more detail.

For example, a curb management system in Washington, DC reduced double parking by 64% and immediately improved safety in crosswalks and bike lanes (Pyzyk, 2019).

COST SAVINGS

The use of computer systems for vehicle routing and scheduling, especially in cases where more than 10 vehicles are needed, usually leads to cost reductions of between 10% and 20% for carriers (Drexl, 2012).

Tire manufacturer Michelin designed EFFIFUEL, a freight logistics ecosystem that includes telematics, training in eco-driving techniques, and an optimized tire-management system. The system can lead to an average annual savings of €3,200 ($3,542 USD, 2016) for long-haul trucks, or at least a 2.1% reduction in total cost of ownership for truck fleet operators (WEF, 2016).

The United Parcel Service's (UPS) Package Flow Technology reduces fuel consumption and emissions by optimizing pickup and delivery allocations and by designing delivery routes that minimize total distance covered, driving time, and idling time. The system also uses historical data to forecast conditions and create routes that eliminate left turns to minimize waiting at lights. In 2009, UPS

reported savings of almost $200 per vehicle per day in fuel costs due to a combination of these strategies (UPS, 2009).

ECONOMIC GROWTH

Digital solutions have transformed the freight logistics industry. In a 2016 white paper, the World Economic Forum estimated that digital technology will lead to the creation of 2 million jobs and reduce carbon emissions by 10 million tons. Overall, the total value impact to the logistics industry was estimated to be $1.5 trillion (WEF, 2016).

ACCESSIBILITY AND EQUITY

Communities of color and low-income neighborhoods are particularly disadvantaged with respect to freight-related congestion, noise, and emissions (EPA, 2014). Digital solutions can direct truck shipments along more equitable routes, shift freight traffic from trucks to other modes, and reduce fuel burn and emissions through use of ITS and V2V/V2I technologies. For example, a StreetLight analysis found that truck activity has a disproportionate impact on disadvantaged communities in New York State in terms of travel time delays, with the average truck delays about twice as long per roadway mile in disadvantaged vs. non-disadvantaged census tracts (StreetLight, 2024).

Digital solutions can direct truck shipments along more equitable routes, shift freight traffic from trucks to other modes, and reduce fuel burn and emissions through use of ITS and V2V/V2I technologies.
See the Intelligent Transportation Systems strategy page for more detail.

RURAL COMMUNITIES

Large volumes of freight either originate in rural areas or are transported through rural areas by road, rail, and waterways. Two-thirds of rail freight originates in rural areas, and nearly half of all truck VMT occur on rural roads (USDOT, 2023). Freight digitalization can improve network efficiency and support the selection of less carbon intensive modes to reduce the impacts of freight transport on rural communities.

AIR QUALITY AND HEALTH

Diesel freight is responsible for significant amounts of particulate matter pollution and adverse health effects, particularly in communities living near highways and ports (EPA, 2014). Digital solutions can support eco-routing and optimize freight movements to minimize impacts to local air quality, e.g., by choosing freight transport with less carbon-intensive modes. A study of geofencing-enabled truck routing in Southern California showed a drop in NOx emissions of 74% in disadvantaged communities when trucks used a “least-emissions path” eco-routing option (Jaller et al., 2021).

COST CONSIDERATIONS

The cost to implement freight digitalization systems varies widely depending on the scale, scope, and location of the project.

The ITS Joint Program Office maintains a list of System Cost Updates for V2X Deployments. Freight-related examples include:

- The Colorado Truck Parking Information Management System (TPIMS) has a total estimated capital cost of $9 million.
- An intelligent truck parking management system using cameras to detect parking availability and automatically notify drivers via a website, in-cab messaging, and roadside dynamic message sign costs $70,000 to $120,000.
- The cost to deploy a real-time truck parking information system was estimated at $391,000 per rest area.

See the Intelligent Transportation Systems strategy page for more detail.

FUNDING OPPORTUNITIES

FHWA's **Saving Lives with Connectivity: Accelerating V2X Deployment** grant program will fund projects that advance connected and interoperable vehicle technologies. Connected and interoperable vehicle technologies have the potential to greatly reduce motor vehicle crashes and resultant fatalities, injuries, and property damage.

USDOT's **Complete Streets AI Initiative** is a $15 million multi-phase effort that will fund small business to develop new decision-support tool(s) for state, local, and tribal transportation agencies that focus on Complete Streets.

FHWA's **Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN)** support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance transportation system efficiency include implementing technology to integration of transportation service payment systems and implanting advanced mobility access and on-demand transportation service technologies.

DOE's **Advanced Research Project Agency (ARPA-E)** is funding projects that develop technology to model the low-carbon intermodal freight transportation system of the future. The projects are expected to reduce emissions by enabling prioritization of low-carbon energy infrastructure deployment, along with data required for the effective deployment of this optimized distribution system.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Delivery/logistics is included as a technology area for eligible projects.

FHWA's **Exploratory Advanced Research (EAR) Program** is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

USDOT's **Reduction of Truck Emissions at Port Facilities Grant Program** provides funding to reduce truck idling and emissions at ports, including through the advancement of port electrification. The program also includes a study to address how ports and intermodal port transfer facilities would benefit from increased opportunities to reduce emissions at ports, and how emerging technologies and strategies can contribute to reduced emissions from idling trucks.

FHWA's **National Highway Freight Program (NHFP)** is aimed at improving the efficient movement of freight on the National Highway Freight Network (NHFN). The program supports investment in infrastructure and operational improvements that strengthen economic competitiveness, reduce congestion, reduce the cost of freight transportation, improve reliability, and increase productivity.

FHWA's **Accelerated Innovation Deployment Demonstration Program** provides funding to State departments of transportation (DOTs), Federal land management agencies, and Tribal Governments to accelerate the implementation and adoption of proven innovative technologies. Project activities may involve any phase of a highway transportation project from project planning through project delivery.

COMPLEMENTARY STRATEGIES

Digital strategies, including smart phone apps and advanced scheduling and routing systems, support micromobility delivery services. Freight digitalization strategies, such as GPS tracking and eco-routing, streamline dispatch and route optimization, enabling micromobility deliveries to efficiently navigate congested urban areas.

Digital solutions can support intermodal freight logistics through advanced tracking and scheduling systems and optimizing freight movements based on commodity, tonnage, and other factors.

Freight digitalization strategies, such as real-time tracking systems and predictive analytics, allow logistics operators to optimize delivery routes and schedules, identifying opportunities for off-peak delivery based on factors like traffic patterns, delivery windows, and customer preferences. In addition, curb reservation systems, common carrier lockers, and other technological solutions can facilitate deliveries during off-peak hours.

Parking reform strategies, such as smart parking, curb management strategies, and other on- and off-street parking solutions for freight deliveries, rely on freight digitalization technology to reduce congestion and time lost to circling and idling.

View All Strategies

CASE STUDIES

PITTSBURGH SMART LOADING ZONES

The City of Pittsburgh and Pittsburgh Parking Authority have implemented Smart Loading Zones, using Automotus curb management technology, as a way to manage curb space to increase delivery efficiency and decrease congestion and emissions at curbs. License plate sensors are used to analyze curbside activity and automate payment for the duration a vehicle is parked at a curb. The smart zones are expected to decrease emissions from unnecessary idling and circling, reduce parking-related congestion, improve pedestrian and cyclist safety, and increase parking turnover in business districts.

FLYTREX DRONE DELIVERY ZONES

Flytrex, a drone delivery service, is currently operating in Texas and North Carolina. Flytrex flies commercial drones and make deliveries to residential backyards and parks for restaurants and retailers. In 2020, the company partnered with the North Carolina Department of Transportation as part of the FAA's BEYOND program which is working towards drone operation without visual ground monitoring. In North Carolina, Flytrex makes deliveries to neighborhoods in Holly Springs, Durham, and Raeford, with plans to expand to additional areas over the next few years. Users can order food and other items from a list of restaurants and grocery stores on an app. The program has been shown to be safe, energy efficient, and can help reduce traffic from delivery vehicles in neighborhoods.

RAILEX PERISHABLES TRANSPORT

Perishables have traditionally been transported almost exclusively by truck (e.g., in 2014, only 2% of fresh produce shipped with the U.S. used intermodal transport). Railex provides transportation and logistics services for perishable cargo. Railex began using refrigerated boxcars and warehouses with climate controls specific to each produce type, automated temperature and humidity controls in railcars, accelerometers to evaluate in-transit events that could damage cargo, and digital inventory management. With the aid of advanced technology, they report cost savings of 10-20% coast-to-coast relative to long-haul trucking.

NASHVILLE SMART CURB ZONE

In 2021, the City of Nashville, in partnership with Coord (now Pebble), a curb management company, launched a Smart Zone Pilot to better manage curb space in the downtown area. Smart Zones enable commercial drivers to use mobile devices to locate, reserve, and pay for time in available loading zones. The Nashville pilot included 14 Smart Zones and over 21 delivery fleets. Nashville was one of four cities selected for Smart Zone pilot in addition to Aspen, CO, Omaha, NE, and West Palm Beach, FL.

Smart Zones allow drivers to find and book available loading zones using a smartphone app (Source: Hammon, 2021).

IMPLEMENTING FREIGHT DIGITAL SOLUTIONS AND EMERGING TECHNOLOGIES: **WHAT TO READ NEXT**

The Urban Freight Lab, a public-private partnership at the University of Washington, provides several resources on the benefits of freight technologies, including:

- Final 50 Feet Research Program: the final 50 feet journey involves a "delivery driver searching for adequate parking, then transferring items from the delivery truck, navigating a route across traffic and through urban obstacle…, concluding when the intended recipient takes receipt of their parcel." Common Carrier Lockers are one digital solution to the final 50 feet problem.
- Curb Occupancy Toolkit: allows for study of the parking behavior of commercial vehicles along the block face and within commercial vehicle loading zones.

The American Council for an Energy-Efficient Economy's (ACEEE) brief, Leveraging Digital Freight Networks to Reduce Emissions, provides policymakers with information on the potential impact of digital freight networks (DFNs) on freight efficiency and emissions in the U.S. Optimizing the movement of goods through information and communications technology (ICT) will be key in achieving substantial reductions in freight-related GHGs.

- DFNs pool data to match shipments to trucks, which can add capacity, improve efficiency, and lower costs to shippers and carriers. Policy makers and industry can coordinate to maximize the benefits of DFNs.
- Uber Freight estimates that with perfect optimization of the U.S. freight network, achieved in part through the use of DFNs, empty miles could be reduced by up to 64% ((Uber Freight, 2023).

In 2022, the International Transport Forum published How Digitally-driven Operational Improvements Can Reduce Global Freight Emissions. The report presents results from a scenario analysis comparing the impact of different freight digitalization strategies on global CO_2 emissions in 2025, 2030, and 2050. Key strategies include: improving truck utilization, strengthening port capacity, adopting

ITS, and reducing intermodal dwell time.

The Truck Parking Information Management System (TPIMS), established with FHWA grant funding by eight member states of the Mid America Association of State Transportation System, provides real time parking availability to drivers along major freight corridors, so that they may proactively plan their routes and make safer, smarter parking decisions.

RESOURCES

GENERAL RESOURCES

FMSCA SAFESPECT Screening Platform**:** FMSCA recently announced this next generation digital inspection platform for commercial vehicle roadside safety inspections. SAFESPECT will improve the efficiency of inspections and decrease wait and vehicle idling time at inspection stations.

FHWA CARMA Program: This program is leading research on cooperative driving automation (CDA) which would enable communication and cooperation between properly equipped vehicles and infrastructure.

DOE CDA Funding Programs: DOE supports CDA research through funding for New Mobility Systems and through the ARPA-E NEXTCAR Program. CDA technologies have the potential to reduce congestion and increase the safety and efficiency of travel on roadways.

FHWA and BTS Freight Analysis Framework (FAF): The FHWA and BTS database contains freight flow data sourced from a variety of sectors, to support freight analysis and inform decision-making. The database provides a comprehensive summary of current freight trends and can be used to predict future trends.

US DOT Freight Logistics Optimization Works (FLOW): Developed by U.S. DOT, FLOW provides an industry forum combined with an information exchange platform to help address supply chain challenges and enable a resilient and globally competitive 21st century freight network.

TOOLS AND MODELING APPROACHES

See the References section for modeling studies on digital freight and associated climate benefits.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

FREIGHT OPERATIONAL STRATEGIES

Freight operational strategies optimize goods movements and mitigate environmental impact, particularly around ports and congested freight corridors, contributing to a more sustainable and resilient supply chain.

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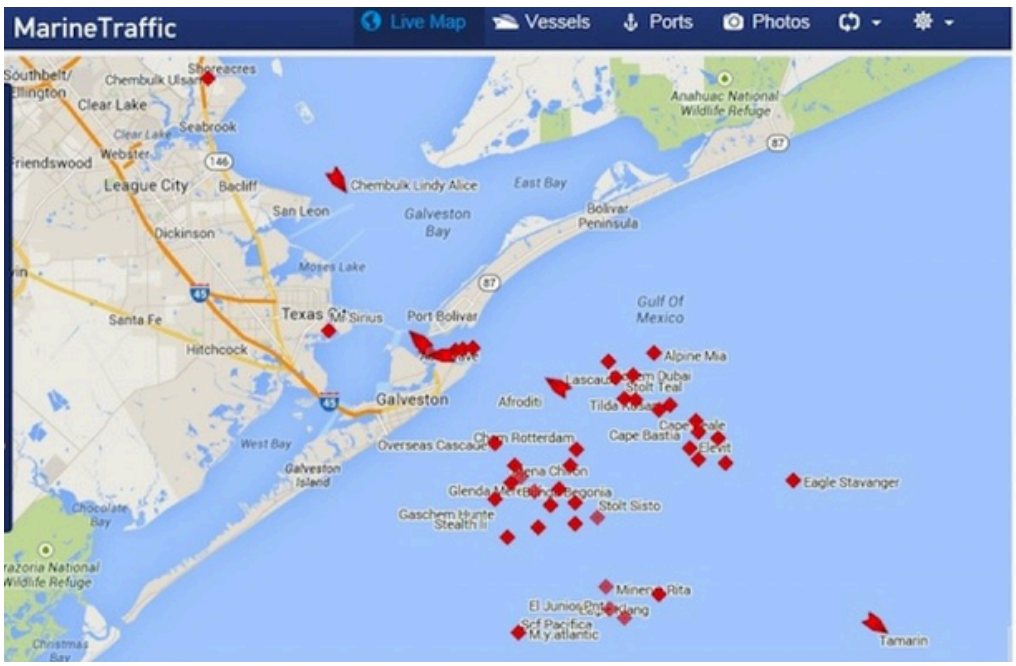
OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural

Freight transportation is a critical component of global commerce and economic vitality. However, goods movement is a significant contributor to greenhouse gas (GHG) emissions and can expose workers and people who live near ports and freight corridors to harmful levels of air pollution and noise. According to the International Energy Agency, **freight transport represents about 8% of global greenhouse gas emissions.**

By leveraging next-generation, clean technologies and practices at ports, State and local governments, alongside port authorities and freight operators, **can improve supply chain efficiency and reduce environmental impact.** Freight operational strategies, such as advanced vessel scheduling and truck appointment systems, can reduce GHG emissions and air pollution and provide time and cost savings. Close collaboration and coordination between the freight industry and communities is key to maximizing these benefits.

Learn more about different freight operational strategies below.



A screenshot of the MarineTraffic Live Map, showing tankers waiting to enter the ports of Houston, Texas City and Galveston (Source: EPA, 2024).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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Freight operational strategies can be broadly categorized into the following groups

Scheduling and Planning

Optimizing schedules for arrivals, departures, and operations such as loading and unloading, and fueling, can significantly reduce congestion and idling times. Utilizing real-time data and communication tools can further enhance efficiency by facilitating coordinated operations. This translates to less queuing and unnecessary engine operation, leading to lower emissions.

Innovative Last Mile Delivery Solutions

These strategies aim to reduce emissions and congestion by optimizing delivery processes and leveraging emerging technologies. Approaches may include micromobility deliveries, consolidated deliveries, off-peak delivery (Read the Off-peak Delivery page), and delivery lockers.

Read more at the *Micromobility Deliveries, Microhubs, and Last-Mile Solutions* page.

Read more at the *Off-peak Delivery* page.

Regulation and Compliance

Implementing clear and enforceable regulations, like anti-idling ordinances, incentivizes wider adoption of clean, environmentally friendly practices. These regulations establish a well-defined framework for reducing idling emissions in specific zones, such as near schools, hospitals, residential areas, ports, railyards, and truck stops, where people are often exposed to concentrated air pollutants. By promoting widespread compliance, anti-idling ordinances contribute to cleaner air in these sensitive locations. Regulations are most effective when complemented with workforce development and training.

Read more at the Idle Reduction Technologies & Strategies page.

Supply Chain Optimization

Optimizing inventory management, packaging and distribution processes, reduces waste and emissions associated with inefficient logistics practices.

Optimal Mode Choice

Freight transportation can be more efficient and reliable when all modes of freight transportation are considered, and the optimal mode is selected. Private industry should consider intermodal freight maritime and rail routes where feasible, to reduce emissions and avoid congestion on roadways.

Read more at the Multimodal and Intermodal Freight Planning page.

Alternative Fuels and Technologies

Promoting the use of zero-emission and low carbon intensity fuels, such as electric vehicles, and hybrid propulsion systems, reduces emissions and leads to cost savings.

Read more at the Electric Vehicle Charging Infrastructure page.

Operations Streamlining

Improving on freight operations through efficient scheduling, routing, and load consolidation helps minimize fuel consumption, reduce emissions, and leads to cost savings.

Specific freight operational practices and procedures may include:

Port Management Information Systems (PMIS)

These electronic tracking systems monitor ship movements, cargo manifests, truck arrivals/departures, and equipment availability. PMIS may focus on a subset of port functions or encompass all freight movement activities, integrating multiple efficiency improvement strategies. Port functions that may be managed by PMIS include:

Advanced Vessel Scheduling: *Also known as virtual vessel arrival, informs vessels about potential delays at destination ports, helping them align arrival times with berth availability and minimize vessel waiting times and associated anchorage emissions. In addition, these systems can help vessel operators optimize their voyage speeds, resulting in further potential fuel savings.*
Many major U.S. ports have implemented PMIS to varying extents including the Port of Virginia, Port Authority of New York and New Jersey, Port of Oakland, and the Port of Los Angeles.

Optimized Drayage Operations: *Drayage efficiency can be improved through various gate management strategies including truck appointment systems and extended operation hours, both of which shift truck arrivals away from peak periods and reduce average wait times at the terminal gates.*

Idle Reduction Technologies (IRT)

IRTs reduce emissions by enabling operators to power essential functions without relying on main engines. This may include shore power, auxiliary power units, battery air conditioning systems, automatic engine stop/start systems, or electrified parking stops.

Read the *Idle Reduction Technologies & Strategies* page.

Just-in-Time (JIT) & Inventory Management

JIT is a form of inventory management that requires working closely with suppliers so that raw materials arrive as production is scheduled to begin, but no sooner. The goal is to have the minimum amount of inventory on hand to meet demand.

Operator Comfort Stations

Offering climate-controlled rest areas at truck stops and railyards reduces idling by ensuring drivers have a comfortable alternative to running engines for climate control during rest breaks.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

FREIGHT EMISSIONS IN CONTEXT

Nearly three-quarters of the world's cargo is moved by ocean-going vessels, but road vehicles make of the majority (about 65%) of freight-related emissions.

In 2019, the three largest ports in the United States in terms of volume processed—the Ports of Los Angeles, Long Beach, and New York and New Jersey—emitted over 2.5 million tons of carbon dioxide equivalents (CO_2e). This estimate includes emissions from ocean-going vessels at port, harbor craft, cargo handling equipment, locomotives, and heavy-duty vehicles (Bertrand and Williams, 2022).

Check out the MIT Climate Portal for more information about how we move our freight.

In 2022, international shipping accounted for about 2% of global energy-related CO2 emissions. Scaling up low- and zero-emission fuels, such as biofuels, methanol, and electricity, is the key to decarbonizing the shipping industry (IEA, 2023).

DRAYAGE TRUCKS

In the National Port Strategy Assessment, the Environmental Protection Agency (EPA) estimates that reducing long-haul truck idle and creep time by 10% reduces CO_2 emissions by 2.6% (EPA, 2016).

If a port with an annual average drayage truck volume of 300,000 and an average turn time of 1.5 hours implemented a gate management strategy that lowered turnarounds to 0.8 hours, they could reduce annual CO_2 emissions by 862 tons per year (EPA, 2021a).

The Global Container Terminals (GCT) Bayonne facility implemented a truck appointment system with a 70% reservation adoption rate. This program

significantly reduced truck turnaround times by 40% during appointment hours leading to CO_2 savings of 21,000 tonnes in 2017. That's equivalent to taking roughly 4,500 passenger cars off the road (EPA, 2018).

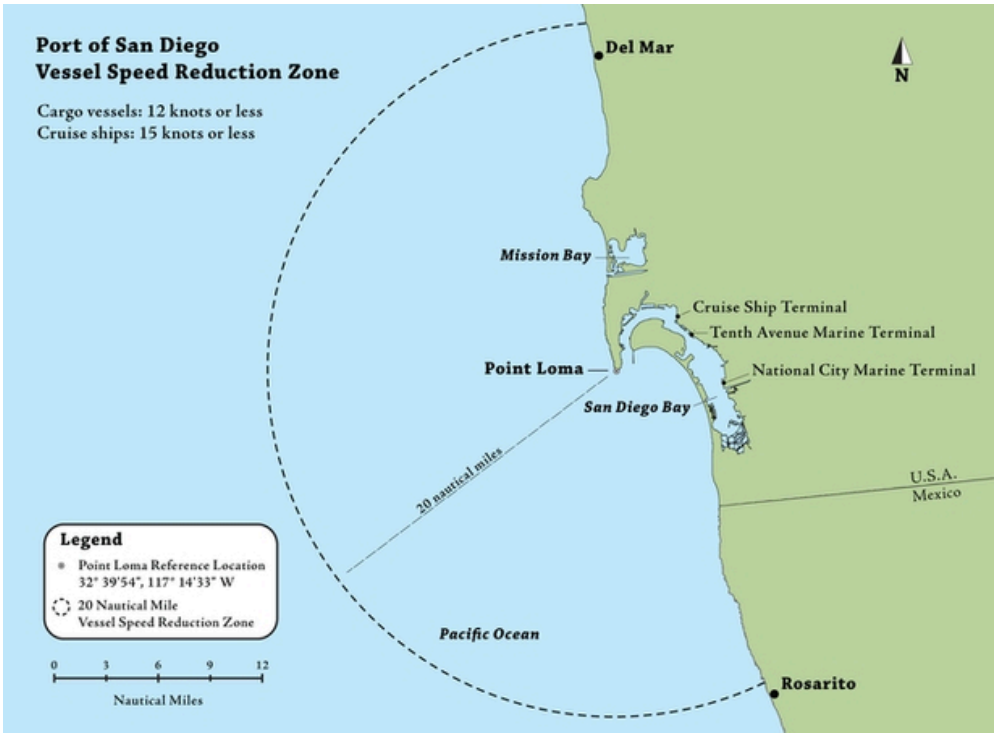
Typical Port Emission Impact for Each 10% Reduction in Idle/Creep Time, 2020 and 2030. (Source: EPA, 2016)

Strategy	NOx		$PM_{2.5}$		CO_2	
	Tons	Percent	Tons	Percent	Tons	Percent
10% reduction in Idle and Creep time	-22	-2.0%	-2	-2.6%	-8,940	-2.6%

OCEAN GOING VESSELS

If an oil tanker with Tier 1 medium speed diesel propulsion engines using marine gas oil originally scheduled to arrive at a port in 184 hours increased its total trip time to 196 hours while en route to avoid an anticipated wait time of 12 hours at anchorage, it could avoid 2.30 tons of CO_2 emissions (EPA, 2021b).

Reducing vessel speeds decreases fuel consumption and emissions near port areas. San Diego, Los Angeles, and New York/New Jersey have established vessel speed reduction (VSR) zones beginning at 20 to 40 nautical miles from shore. As one example, the Port of Los Angeles VSR reduced average vessel speeds to 12 knots within 24 nautical miles, resulting in 37% CO2 emissions savings (EPA VSR, n.d.).



Port of San Diego Vessel Speed Reduction Zone (EPA VSR, n.d.).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Reduced engine noise associated with idling can create a safer working environment for port personnel. Regular exposure to high noise levels can lead to occupational hearing loss, which is associated with heart problems, cognitive decline, and poor mental health (CDC, 2024).

Reduced engine noise associated with idling can create a safer working environment for port personnel. Regular exposure to high noise levels can lead to occupational hearing loss, which is associated with heart problems, cognitive decline, and poor mental health (CDC, 2024).

ACCESSIBILITY AND EQUITY

Near-port communities are often low-income communities of color and suffer disproportionate impacts from port operations. Addressing noise and air pollution from truck traffic, train traffic, and idling vessels can reduce impacts on these communities (EPA, 2023; EPA, 2024).

For resources on community-port collaboration, including toolkits, roadmaps, and primers, visit the EPA Ports Initiative site.

ECONOMIC GROWTH

Idle reduction operational strategies, such as advanced scheduling, contribute to smoother operations by minimizing delays. This translates to increased efficiency, potentially leading to higher throughput (EPA, 2019).

Ports can implement several programs and policies that spur investment in local entrepreneurs and the local workforce. These programs can be tailored to emphasize investments in near-port communities and/or communities experiencing high rates of poverty, unemployment and underemployment (EPA, n.d.).

According to the American Association of Port Authorities, deepwater ports in the U.S. supported 541,946 jobs in 2014. In addition, port activity generated over 23 million jobs in related sectors and through their overall economic impact on the surrounding communities (American Association of Port Authorities, 2014).

AIR QUALITY AND HEALTH

Port operations can impact air quality, water quality and land use. Research suggests idling may contribute up to 34% or more to local air pollution levels (Lee et. al., 2017). By increasing port operational efficiency and reducing the movement and idling of vessels, vehicles, and equipment, port management information systems (PMIS) can significantly reduce port-related emissions and noise which can improve the health of port workers and nearby communities (EPA, 2016; EPA, 2024).

Vessel speed reduction zones can have significant benefits for near-port air quality. If a container ship with a typical cruising speed of 21 knots reduced its speed by 20% to 16.8 knots, it would see a reduced engine load of up to 50% and corresponding reductions in fuel consumption and NOx and PM emissions (EPA VSR, n.d.).

COST SAVINGS

Vessel operators typically travel at full speed to destination ports. Knowing about berthing delays in advance allows them to reduce their speed, resulting in fuel savings and emissions reductions en route (EPA, 2021b).

Global Container Terminals (GCT) estimates that an integrated appointment system at the GCT Bayonne facility at the Port of New York and New Jersey improved truck turn times by over 40% (EPA, 2018).

A typical long-haul combination truck that eliminates unnecessary idling could save over 900 gallons of fuel each year (EPA, 2019).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

Anti-idling Programs: The capital costs for implementing and maintaining an anti-idling policy are low, typically limited to signage (around $50) and incorporating the policy into existing employee training sessions (EPA, 2019).

Comfort Stations: Providing basic amenities like restrooms at facilities incurs minimal to no cost. However, enhancing these areas with amenities like comfortable seating, vending machines, Wi-Fi, and electrical outlets will increase costs depending on the level of improvement chosen (EPA, 2019).

Port Management Information Systems (PMIS): PMIS implementation costs vary significantly depending on the size and complexity of your port operation. Factors include installation costs, software licenses, and any necessary equipment (EPA, 2024).

Cost savings from implementing a PMIS can be sizable as a result of reduced fuel consumption, and reduced fees and fines associated with idling and demurrage fees (EPA, 2021a).

Extended Gate Hours: Labor costs associated with extended hours will depend on staffing needs, wages, and benefits.

FUNDING OPPORTUNITIES

EPA's **Clean Ports Program** provides for investment in clean, zero-emission port equipment and technology; to conduct relevant planning or permitting in connection with the purchase or installation of such equipment or technology; and to help ports develop climate action plans to reduce air pollutants at U.S. ports.

FHWA's **Congestion Mitigation Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. This includes certain freight projects that reduce emissions. For more information, please see the CMAQ Interim Guidance.

EPA's **Diesel Emissions Reduction Act (DERA) Program** funds grants and rebates that protect human health and improve air quality by reducing harmful emissions from diesel engines.

USDOT's **Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Discretionary Grant program** funds critical infrastructure projects across the country, prioritizing sustainability and equitable access.

FHWA's **Truck Emissions at Port Facilities (RTEPF) Grant Program** provides funding to test, evaluate, and deploy projects that reduce port-related emissions from idling trucks. Eligible projects include port electrification and efficiency improvements, focusing on heavy-duty commercial vehicles, and other related projects.

Honolulu, Hawaii: Truck Emissions at Port Facilities Grant Award The Hawaii Department of Transportation will receive $5.2 million to modernize port gates and automate improvements at the Sand Island Terminal in Honolulu Harbor. The improvements will reduce truck processing times, queueing delays, cut port-related emissions from idling trucks and make port operations more efficient.

San Juan, Puerto Rico: Truck Emissions at Port Facilities Grant Award Crowley Logistics, Inc. will receive $3.8 million to reduce truck emissions, queueing, idling and traffic congestion at the Isla Grande Terminal at the Port of San Juan in Puerto Rico. The project includes replacing diesel-powered trucks with electric utility tractor rigs and installing fast chargers. Crowley's supply chain operations in the Southeast and Gulf Coast account for more than 60% of domestic cargo moved to/from Puerto Rico.

Idle Reduction Equipment Excise Tax Exemption: Qualified on-board idle reduction devices and advanced insulation are exempt from the federal excise tax imposed on the retail sale of heavy-duty highway trucks and trailers. The exemption also applies to the installation of qualified equipment on vehicles after the vehicles have been placed into service.

MARAD's **Port Infrastructure Development Program** supports projects that improve the safety, efficiency, and reliability of moving goods into, out of, around, or within ports.

COMPLEMENTARY STRATEGIES

IRTs can work alongside other operational improvements like traffic management systems or optimized scheduling to further streamline port operations and reduce overall environmental impact.

Upgrading existing engines with cleaner technology or transitioning to zero-emission alternatives like electric trucks or hydrogen-powered cargo handling equipment can significantly improve air quality and contribute to achieving ambitious climate goals.

The relationship between intermodal freight and freight operational improvements lies in how operational enhancements can improve the effectiveness of intermodal freight while reducing GHG emissions. For example, real-time tracking and data analytics can optimize intermodal routes, minimize transit times, and improve supply chain visibility. Automation and digitalization can streamline intermodal operations, reducing manual errors and delays.

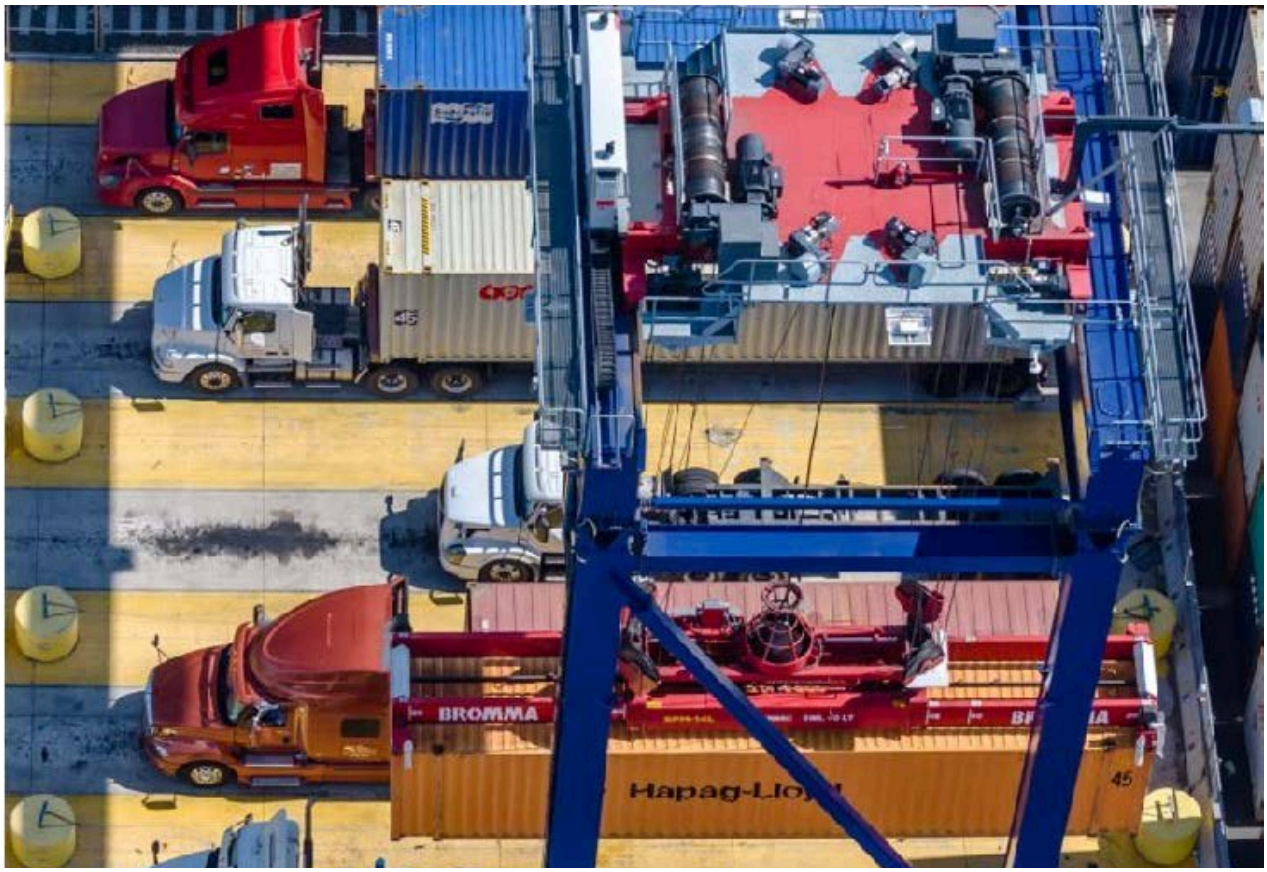
Leveraging compact vehicles like cargo bikes, drones, and delivery robots as agile, last-mile solutions enhances the final, and often complex and costly, component of freight delivery.

By scheduling deliveries during non-peak hours, off-peak deliveries enhance operational efficiency, enhance reliability of timely deliveries, and reduces emissions caused by congestion.

View All Strategies

CASE STUDIES

MIAMI, FLORIDA: TRUCK EMISSIONS AT PORT FACILITIES GRANT AWARD



Source: U.S. EPA Ports Initiative

Jacintoport International will receive $1.8 million to install new terminal operating systems at the Seaboard Marine Port in Miami. The terminal improvements will reduce truck idling time at the gates by at least 10 minutes, which, in turn, will ease truck congestion within the port and roads leading to the ports. The new system will improve the efficiency of trucks picking up or dropping off containers in the yard, reducing their operating time, the amount of carbon emissions, air pollutants and noise associated with idling trucks and equipment.

PORT OF VIRGINIA

The Port of Virginia is one of the fastest growing ports on the East Coast, its largest terminal, the Norfolk International Terminal, encompasses 567 acres and has over 2,147,200 twenty-foot equivalent unit (TEU) capacity. However, trucks servicing the port often experienced lengthy wait times, which created bottlenecks and led to vehicle idling. To relieve congestion, the port implemented an electronic appointment system in 2014.

Source: Port of Virginia

What is TEU?

TEU, or Twenty-foot Equivalent is commonly used unit to determine cargo capacity.

The newly integrated system works across various port operations and includes:

- A reservation system for gate appointments and support.
- A community portal for import and export cargo and vessel schedules.
- A mobile app for import container availability.
- A drayage truck registry with RFID tag support, distribution, and management services.

Furthermore, the system allows for two-way data flows with other supply chain stakeholders. This single window collaboration platform has helped decrease truck turn times by nearly 50%, leading to improved traffic conditions and a 20% reduction in truck-related emissions (EPA, 2021a).

IMPLEMENTING FREIGHT OPERATIONAL STRATEGIES: **WHAT TO READ NEXT**

Enacting anti-idling regulations or time limits can be a readily implementable strategy for various sectors. These regulations are often already established around schools, hospitals, and other sensitive areas, providing a familiar framework for broader adoption.

- Sample Idle Reduction Policy and Policy Guidance available, here.

- Sustainable Environment for Quality of Life hosts a Sample School Bus Anti-Idling Policy online. The policy, as well as other action steps are detailed here.

Near-port communities (communities that are within a 7-mile radius of the proposed Inland Port) and port operators have unique challenges and shared interests related to air quality that can benefit from joint problem solving. Community-port collaboration is important to address environmental justice concerns and improve quality of life for near-port communities and port workers. Collaboration with community partners can also help ports achieve better infrastructure project outcomes, increase resilience, and manage risk (EPA, 2023).

Source: U.S. EPA, Community-Port Collaboration

- Read more at EPA's Community-Port Collaboration Toolkit, here.

Success Story

The Port of Long Beach, California partners with the Long Beach Unified School District to support the innovative Academy of Global Logistics at Cabrillo High School, a four-year pathway for students interested in trade and maritime careers. The Port links with Long Beach City College and California State University, Long Beach, to offer training, study pathways for logistics careers, and professional development programs. New grant-funded demonstrations of zero-emissions and other clean port technology include workforce development and training outreach for local jobseeker (Port of Long Beach, 2019).

Ports that implement vessel scheduling, drayage operations, automated gate systems, and other PMIS can improve overall efficiency and benefit surrounding communities.

Read about Port Management Information Systems, here

RESOURCES

GENERAL RESOURCES

The EPA Ports Initiative: This initiative works with U.S. ports and local communities to improve environmental performance. The program provides technical resources, such as guides on creating port emission inventories, and toolkits and resources to promote community-port collaboration. The Ports Initiative is currently running pilot projects at four ports to provide technical assistance for community collaboration.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Idle Reduction: This resource provides an introduction to idle reduction practices, their benefits, and resources for personal and commercial vehicles.

U.S. Environmental Protection Agency Best Clean Air Practices for Port Operations: This resource offers best practices for ports to reduce air pollution, potentially including strategies to minimize idling times from ships and cargo handling equipment.

TOOLKITS AND MODELLING APPROACHES

USDOT's Freight Logistics Optimization Works (FLOW): FLOW is a public-private partnership among industry and government to help build a forward-looking, integrated view of supply chain conditions in the U.S. The program collects purchase order information from importers in addition to logistics supply, demand, and throughput data from participants, which the Bureau of Transportation Statistics analyzes and provides a broad, daily view of the current conditions of the overall logistics network back to FLOW members.

Federal Highway Administration, Congestion Mitigation Air Quality Improvement (CMAQ) Emissions Calculator Toolkit, Diesel Idle Reduction Strategies: This tool provides air quality benefit calculations for diesel idle reduction strategies.

U.S. Environmental Protection Agency, Diesel Emissions Quantifier (DEQ): This tool allows users to estimate air pollutant emissions from various sources, including idling diesel vehicles.

Argonne National Laboratory, Vehicle Idle Reduction Savings Worksheet: This downloadable spreadsheet helps calculate potential fuel cost savings associated with reducing vehicle idling times.

U.S. Department of Energy, Petroleum Reduction Planning Tool: This online tool helps assess strategies and opportunities for reducing petroleum use across different sectors, including potential benefits from reducing vehicle idling.

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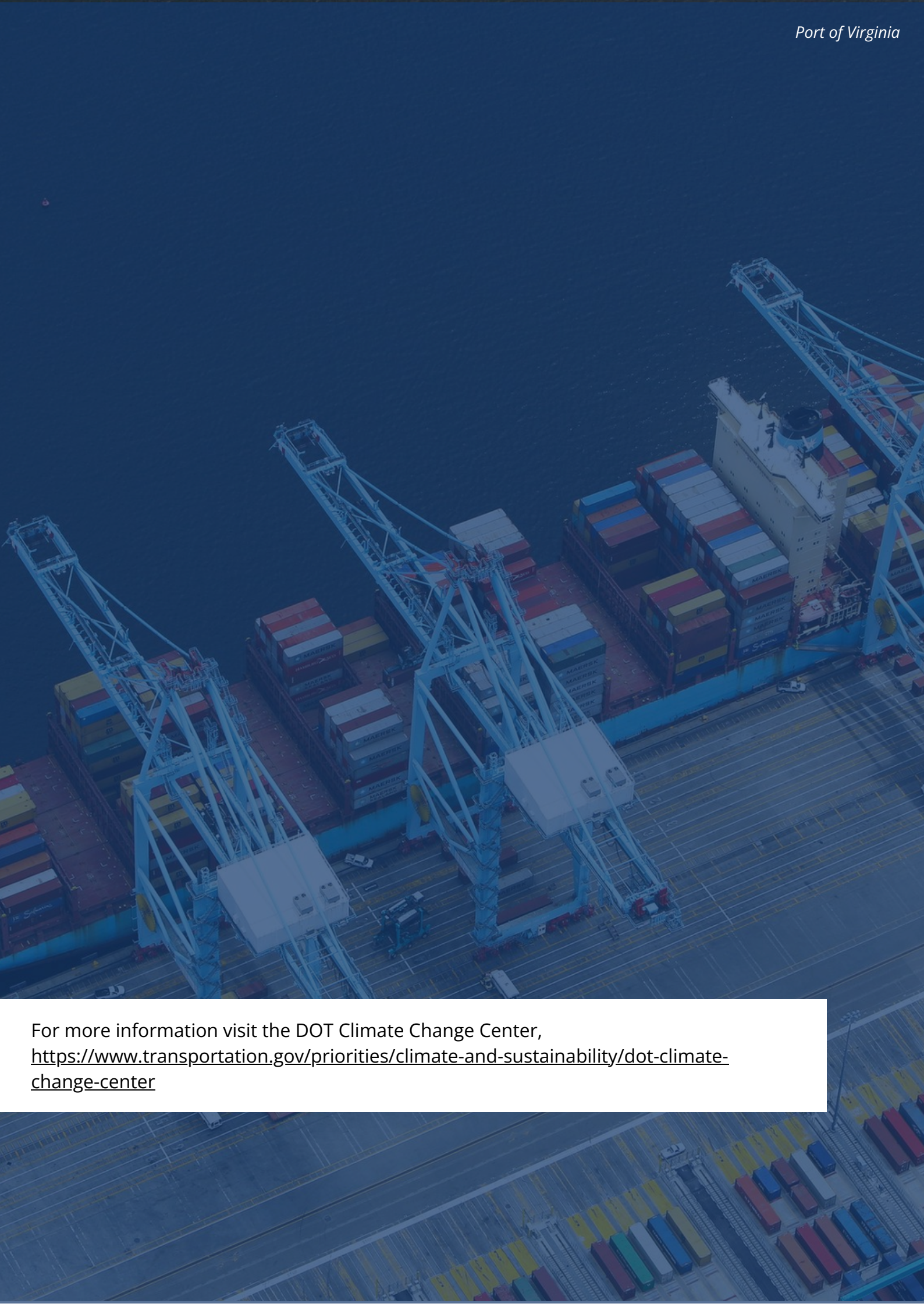

Port of Virginia

For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

HEAVY-DUTY DIESEL ENGINE RETROFIT AND REPLACEMENT

Retrofitting or replacing heavy-duty diesel engines cuts fuel use and associated emissions, contributing to cleaner air for local communities.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural, & Tribal

Heavy-duty vehicles and engines are significant contributors to greenhouse gas emissions and local air quality issues. Typical diesel engines in heavy-duty trucks, locomotives, port equipment, and marine vessels can last up to 30 years. The Environmental Protection Agency (EPA) estimates that over 10 million older diesel engines are in use today. Older engines are less efficient and less likely to have exhaust treatment devices like catalytic converters and diesel particulate filters. **Newer and more efficient engines have lower fuel consumption and help reduce costs in the long term.** Newer engines and vehicles have built-in fuel savings and emission controls, such as selective catalytic reduction, exhaust gas recirculation, and aerodynamic features.

Select components of diesel engines can be replaced as a more cost-effective alternative to whole vehicle or engine replacement. Engines can also be modified to use lower carbon intensity fuels, such as biodiesel, or more than one fuel (e.g., dual-fuel diesel or flexible-fuel engines). Heavy-duty engine and vehicle upgrades have the potential to improve air quality and reduce health impacts from diesel particulate matter and NOx emissions, particularly along major freight corridors, in downtown cores, and in and around ports.

Decarbonization strategies for heavy-duty equipment may include:

- Whole engine replacement
- Replacing specific engine components
- Exhaust and engine retrofit
- Aerodynamic designs and devices
- Idle reduction technologies

Replacing and retrofitting non-road engines can lower the carbon footprint of ports, railyards, and intermodal facilities and improve air quality for nearby communities. Non-road equipment includes locomotives, barges and other marine vessels, and cargo-handling equipment such as loaders, cranes, and drayage trucks.

Transitioning to lower emissions vehicles can be a challenge for the many small trucking companies and owner-operators. Over 95% of U.S. trucking companies have fewer than 10 trucks (American Trucking Association, 2024) and may not have the resources to plan ahead for lifecycle retrofits or turnover. **Larger fleets may be better suited to lead this transition.**

Source: EPA Diesel Emissions Reduction Act

Spotlight on the Ports of Los Angeles and Long Beach (San Pedro Ports)

These ports have been leading the way with zero-emissions equipment and a path to a net zero-emissions future. Recent efforts have focused on deploying electric yard tractors, drayage trucks, and cargo handling equipment (CHE). **CHE accounts for nearly 15% of CO_2 emissions and 5% of NOx emissions at the ports.** The ports have set a near-term goal of transitioning to a 100% zero-emission drayage truck fleet by 2035.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

REGULATIONS SUPPORT DECARBONIZATION OF THE HEAVY-DUTY SECTOR

EPA's 2021 Clean Trucks Plan describes EPA's efforts to reduce GHG emissions and air pollutants from heavy-duty trucks through a series of rulemakings. The Phase 3 Greenhouse Gas Rule, which builds on two previous rulemakings, will further reduce GHG emissions from heavy-duty vehicles and engines, including vocational vehicles (such as delivery trucks, refuse haulers, public utility trucks, transit, shuttle, school buses, etc.) and tractors (such as day cabs and sleeper cabs on tractor-trailer trucks). The Phase 3 rule applies to model years 2027 through 2032 and allows manufacturers to choose what set of emissions control technologies (battery electric, fuel cell etc.) is best suited for their vehicle fleet. The revised emissions standards will help avoid approximately 1.8 billion metric tons of GHGs, over 50,000 tons of NOx, and 113 tons of $PM_{2.5}$ from 2027 through 2055 (EPA, 2024).

In 2023, the European Commission proposed a revision of the Regulation on CO_2 emission standards for heavy-duty vehicles. If adopted, the proposal will introduce more stringent standards in 2030 and beyond and extend the current regulation, which covers large trucks, to cover smaller trucks, city buses, long-distance buses, and trailers. The new standards are expected to decrease CO_2 emissions per km from new heavy duty vehicles by 90% by 2040, as compared to the reference period (1 July 2019 – 30 June 2020), with intermediate targets for 2030 (45%) and 2035 (65%). The regulation will also include an incentive mechanism for zero-emission and low-emission vehicles (European Commission, 2023).

TECHNOLOGIES THAT REDUCE FUEL CONSUMPTION AND EMISSIONS

Engine, vehicle, and transmission technologies that reduce truck fuel consumption will also reduce CO_2 emissions. A study by the Northeast States Center for a Clean Air Future (NESCCAF) and the International Council on Clean Transportation (ICCT) found that a combination of technologies can provide fuel savings of over 40% when applied to large tractor-trailers (NESCCAF et al., 2009).

Both battery electric and plug-in hybrid delivery trucks can achieve energy savings and reduce liquid fuel use. With appropriate en route charging, e-trucks can reduce overall energy costs by 29 to 44% (Gao et al., 2017).

Fuel cell electric vehicles emit only water vapor, producing no harmful tailpipe emissions. An International Council on Clean Transportation study compared the lifecycle greenhouse gas emissions from diesel and hydrogen trucks and buses in Europe and found that vehicles running on hydrogen produced from fossil fuels reduce GHG emissions by 15% to 33% compared to their diesel counterparts. If hydrogen is produced solely with renewable electricity, emissions can be reduced by up to 89% (O'Connell et al., 2023).

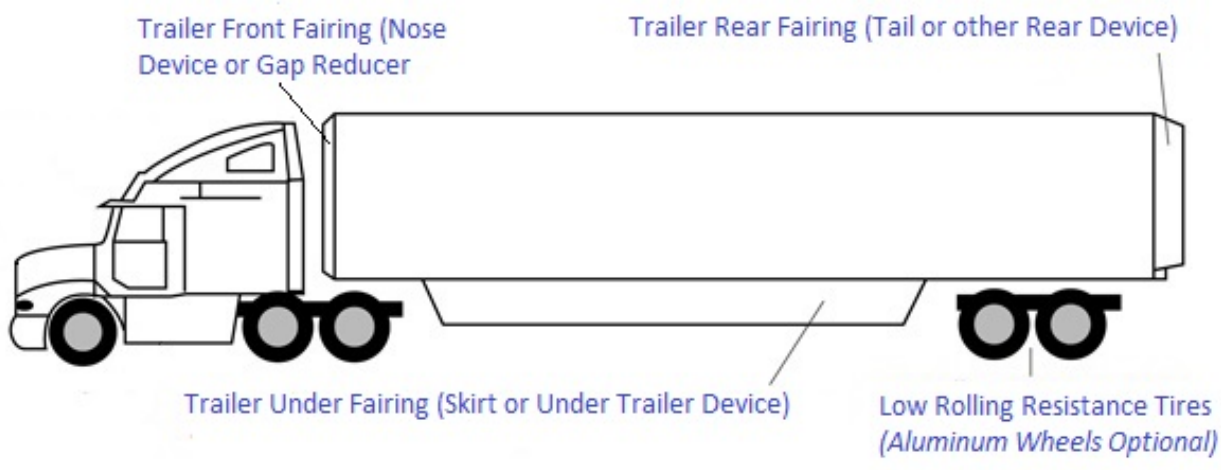
As hydrogen costs come down and fueling infrastructure expands, fuel cell electric vehicles will become a viable technology for heavy-duty applications. Learn more at the Department of Energy (DOE)'s Hydrogen and Fuel Cell Technologies Office (HFTO) website.

Upgrading a model year 2012 combination long-haul truck (Class 8) to an electric vehicle with aerodynamic components can save more than 15,000 gallons of fuel and nearly 200 tons of CO_2 emissions annually (EPA, n.d.).

Electric school buses produce less than half the GHG emissions of diesel and propane-powered school buses, including accounting of emissions from electricity generation (WRI, 2023).

Over three quarters of fuel consumption by medium and heavy-duty vehicles is due to the largest Class 8 vehicles (33,001 lb. and over). The most common Class 8 truck is the tractor-trailer combination, which is primarily employed in long-distance freight operations. Programs that target Class 8 energy efficiency may see the most significant CO_2 emissions reductions (NESCCAF et al., 2009).

EPA-designated SmartWay Tractors and Trailers are long-haul freight vehicles that significantly lower fuel consumption and emissions of air pollutants. These tractors and trailers have been tested and validated by EPA to meet specifications for fuel savings (EPA, 2024).



SmartWay Designated Trailer with Aerodynamic and Tire Components

SmartWay Trailer Specifications

	SmartWay Trailer	**SmartWay *Elite* Trailer**
Tires	Verified Low Rolling Resistance Tires (1% fuel savings)	
Aerodynamic Devices	One or more devices (at least 5% fuel savings)	Combination of two or more devices (at least 9% fuel savings)
Total Fuel Savings	6% or more	10% or more

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

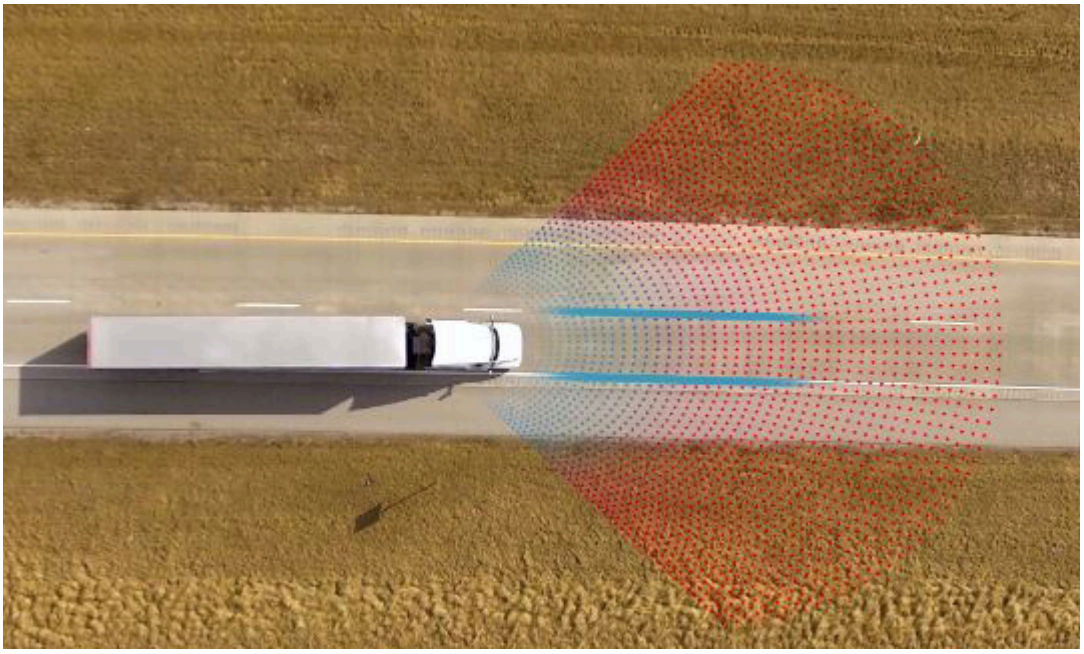
SAFETY

Many newer heavy-duty vehicles include safety features, such as collision warning and blind spot warning, which can help make streets safer for other vehicles and vulnerable road users (FMCSA, 2021).

An analysis of real-world data from 117 truck fleets found that trucks equipped with lane departure warning technology had a 21% lower crash rate compared to trucks without the technology (Routhier, 2024).

COST SAVINGS

Converting diesel truck fleets to newer model years or low and zero-emission vehicles can reduce overall maintenance and fuel costs for freight carriers. One research study found that per-mile maintenance costs for medium- and heavy-duty diesel engines increase by about 4-fold between the 0 to 50,000 and 50,000 to 100,000 mileage intervals (Boyce, 2022).



Lane Keep and Lane Centering Technology
(Source: Federal Motor Carrier Safety Administration)

AIR QUALITY AND HEALTH

Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways and ports (EPA, 2014).

The National Renewable Energy Laboratory analyzed baseline air pollutant concentrations in the Los Angeles area and changes to pollutant concentrations associated with electrification of heavy-duty trucks (Ravi et al., 2023):

- Although they account for only 5% of registered vehicles in the area, heavy-duty trucks contribute 51% of on-road nitrogen oxide emissions.
- Prioritizing electrification of trucks close to highways provides significant benefits to air quality-impacted disadvantaged communities.
- If 25% of trucks in Los Angeles are electrified, the number of annual avoided premature deaths due to $PM_{2.5}$ exposure will fall by over 50.

RURAL COMMUNITIES

Large volumes of freight either originate in rural areas or are transported through rural areas by road, rail, and waterways. **Two-thirds of rail freight originates in rural areas, and nearly half of all truck vehicle miles traveled (VMT) occur on rural roads** (USDOT, 2023). Upgrading heavy duty fleets to cleaner, more efficient versions can reduce noise and air quality impacts on rural communities.

Rural school districts often operate large fleets of school buses due to considerable distances between children's homes and schools. As part of the Clean School Bus Program, EPA prioritizes funding to rural and low-income areas. Upgrading rural fleets to low- or zero-emissions vehicles reduces emissions and exposure to toxic pollutants.

Read more about the program here.

Source: U.S. EPA Clean Bus Program

ACCESSIBILITY AND EQUITY

Near-port communities are often low-income communities of color that suffer disproportionate impacts, including noise and air pollution, from port operations.

- The population within 2 miles of the Port of Houston is comprised of 76% people of color (EPA Environmental Justice Primer for Ports).
- Fifty-eight percent of Los Angeles disadvantaged communities have high traffic impacts or diesel particulate matter exposure, and 32% of disadvantaged communities have both (Ravi et al., 2023).

Students from low-income families are exposed to higher levels of diesel exhaust pollution from school buses: 60% of these students ride the bus to school, compared to 45% of students from higher income families. Black and brown students and children with disabilities also rely on school buses more than their peers. Electrifying school bus fleets can help address these health concerns and inequalities (WRI, 2023).

Several federal and state programs that support heavy-duty vehicle upgrades prioritize projects in disadvantaged communities.

The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project HVIP includes a disadvantaged community incentive of 15% for vehicles that are purchased or leased by a public or private small fleet with 20 or fewer trucks or buses and less than $15 million in annual revenue for private fleets. Vouchers are also available for any purchase or lease by a California Native American tribal government (CARB, n.d.).

COST CONSIDERATIONS

Here are a few ballpark numbers from recent electric and alternative fuel truck projects:

- The Port of Oakland recently acquired 10 Peterbilt 579EVs at a cost of $5.1 million, or about $510,000 per semi-truck.
- Through the Reduction of Truck Emissions at Port Facilities Grant Program:
  - Puerto Rico Terminals received about $2.8 million to replace 7 diesel trucks with all-electric versions at the Port of San Juan and install 7 fast-charging stations.
  - Louisiana received $7.1 million to purchase 14 all-electric heavy-duty terminal trucks and five light-duty pickup trucks and support electrical infrastructure upgrades.
  - New Jersey received $2.2 million to replace 20 diesel trucks with new, low emissions propane versions – about $110,000 per truck.
  - The Northwest Seaport Alliance received $16 million to provide financial incentives to independent owner-operators and small trucking companies in the Seattle-Tacoma region to buy zero-emission, short-haul trucks. This funding will support between 36 and 58 truck purchases along with corresponding charging/fueling infrastructure.

Considering equipment costs, fuel and electricity costs, and other costs such as maintenance and insurance, the total annual costs for a diesel vs. electric city delivery truck are relatively similar ($47,700 vs. $45,200) (DANA, n.d.). Federal and state rebates may help further reduce costs of electric equipment.

Heavy-duty engine technologies that reduce fuel consumption and emissions range in cost from a **few hundred dollars for simple retrofits** to **$2,000-$3,000 for a turbocompound package** to **$20,000+ for more advanced technology packages** (NESCCAF et al., 2009). The cost of a **new semi-truck ranges from approximately $70,000 to $180,000**.

FUNDING OPPORTUNITIES

EPA's **Diesel Emissions Reduction Act (DERA) Program** funds grants and rebates that protect human health and improve air quality by reducing harmful emissions from diesel engines. DERA funds can be used to fund retrofit and replacement of diesel equipment, including school buses and transit buses.

EPA's **Clean Heavy-Duty Vehicle Program** offers grants and rebates to replace existing heavy-duty vehicles with clean, zero-emission vehicles.

EPA's **Clean Ports Program** provides for investment in clean, zero-emission port equipment and technology; to conduct relevant planning or permitting in connection with the purchase or installation of such equipment or technology; and to help ports develop climate action plans to reduce air pollutants at U.S. ports.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including supporting heavy-duty engine and vehicle replacement and retrofit projects.

California Truck Replacement Programs, including the **San Joaquin Valley Air Pollution Control District program**, replace on-road diesel trucks with alternative technology units. Projects that will accelerate emission reductions in low income and disadvantaged communities experiencing greater air quality impacts may receive priority through the project review and selection process.

COMPLEMENTARY STRATEGIES

Heavy-duty vehicles spend considerable time idling with their engine on – school buses idle at bus stops, transit buses idle at curbs and park-and-ride lots, and trucks idle during deliveries and for longer periods of time at roadside rest stops. Idle reduction technologies can contribute to improved fuel efficiency and lower emissions.

Heavy-duty vehicles typically have relatively low fuel efficiency. Upgrading to newer engines and vehicles and retrofitting engines with emissions control technologies can improve the overall efficiency of heavy-duty fleets.

View All Strategies

CASE STUDIES

ELECTRIC REFUSE TRUCKS AT REPUBLIC SERVICES

Republic Services, in partnership with Oshkosh Corporation, released the first electric garbage truck fleet in fall 2023 in Phoenix, AZ and plans to roll out electric fleets in other U.S. cities, including Carlsbad, CA and Portland, OR in 2024. Republic expects electric vehicles to represent half of their new truck purchases by 2028.

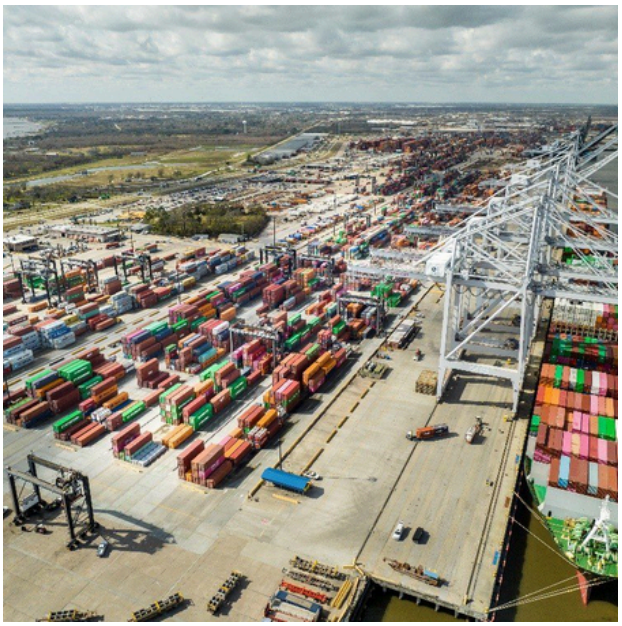
Source: Republic Services

MESILLA VALLEY TRANSPORTATION (MVT) SMARTWAY PARTNERSHIP

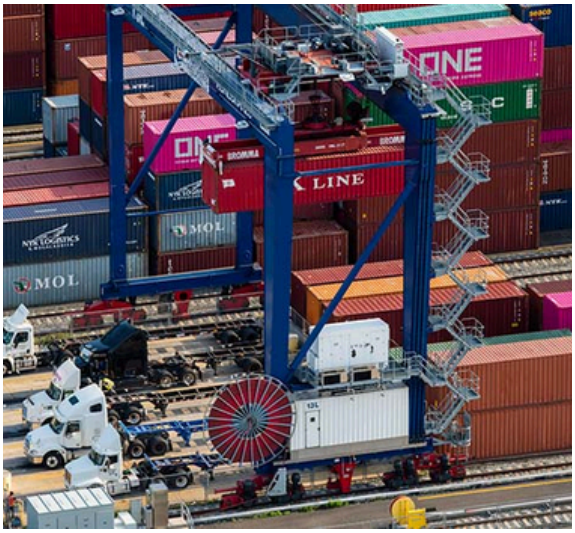
MVT is one of the largest truck load carriers in the U.S., operating routes between major manufacturing areas in the U.S., Canada, and Mexico. The company joined EPA's SmartWay program in 2004 and immediately began a fuel economy benchmarking exercise. Due to the size and age of its fleet, routes, and other factors, their fleetwide average was only 6.8 mpg. To improve fuel efficiency, MVT switched to trucks and trailers with single wide-based tires, equipped all trucks with direct-drive transmissions and idle reduction devices, and installed various aerodynamic features, including run skirts and trailer tails. MVT also provides training on smoother driving practices and offers financial incentives to drivers who achieve 8.6 mpg and above. MVT's fleet is now running close to 9 mpg and saves approximately 20,000 gallons of fuel monthly compared to 2004 levels.

PORT DRAYAGE TRUCK REPLACEMENT PROGRAM - PORT OF NY/NJ

The Port Drayage Truck Replacement Program (TRP) at the Port of New York and New Jersey is a voluntary subsidy program which encourages replacement of old heavy-duty diesel trucks with newer models. If all eligible trucks (ca. 5,600) are replaced, the port would see annual emissions reductions of 98.5 tons of NOx (13%) as well as sharp reductions in $PM_{2.5}$ and CO_2 emissions. The lower NOx emissions are expected to reduce local NOx concentrations by up to 63%, bringing levels below what is considered hazardous to human health and significantly improving air quality for vulnerable populations living near the port.



Source: Port Houston



Source: National Renewable Energy Laboratory

REDUCING EMISSIONS AND NOISE AT TRUCK BOTTLENECKS - HOUSTON, TX

The Barbours Cut Container Terminal is located on Galveston Bay near the inlet to the Houston Ship Channel. Poor air quality is a concern locally and regionally and the terminal is bordered by residential neighborhoods. As part of a case study in the Reducing Emissions and Noise at Truck Bottlenecks report, FHWA tested seven strategies for emissions impacts and found that clean trucks, drayage optimization strategies, and rail drayage could have significant emissions benefits for the region. For example, retiring and replacing 17% of the study area's trucks (all pre-2007 models) would reduce emissions of most criteria pollutants by 20-60% and reduce GHG emissions by 4%.

IMPLEMENTING HEAVY-DUTY DIESEL ENGINE RETROFIT AND REPLACEMENT: **WHAT TO READ NEXT**

Industry, often through partnerships with the public sector, is leading the way with reducing emissions from heavy-duty fleets. EPA develops new vehicle and engine standards with feedback from industry and trade groups. Vehicle and equipment manufacturers in turn develop new technologies to meet the standards. Consumers are also increasingly focused on buying sustainable products and services, which puts pressure on companies to offer cleaner, more efficient alternatives.

Source: EPA Smartway

EPA's SmartWay Program provides resources to fleet managers, carriers, and other stakeholders involved in freight transport to help advance supply chain sustainability. The program helps companies identify and select more efficient freight carriers, transport modes, equipment, and operational strategies to improve supply chain sustainability and lower costs from goods movement.

See lists of SmartWay-verified Technologies and Tractors & Trailers.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

EPA's Ports Initiative works in collaboration with the port industry, communities, and state and local governments to advance clean technologies and practices at ports. The Ports Initiative and Clean Ports Program website provides many technical resources for ports, guidance on community-port collaboration, and funding opportunities.

State and local incentive programs for low-emission and zero-emission heavy-duty vehicles can help encourage the transition of truck fleets to cleaner options. For example, California's HVIP provides base vehicle price breaks from $20,000 to $240,000, depending on the vehicle purchased (CARB, n.d.).

RESOURCES

GENERAL RESOURCES

FHWA's Study on Assessing Truck Emissions and Noise at Truck Freight Bottlenecks: This report discusses strategies to address truck emissions and noise at truck freight bottlenecks, including significant highway bottlenecks and truck access to intermodal connectors. The report includes case studies to demonstrate the potential benefits of various mitigation strategies at specific locations.

EPA SmartWay Program: This program promotes freight transportation efficiency and fuel-saving technologies. The SmartWay Transport Partnership is a collaboration between EPA and the freight industry – it is voluntary and uses strong market-based incentives.

EPA Regulations for Emissions from Vehicles and Engines: The EPA regularly revises regulations including standards for heavy-duty vehicles. The latest information on air pollutant and GHG emission standards for on road and nonroad vehicles and engines can be found at the EPA site.

North American Council for Freight Efficiency (NACFE) Medium-Duty Electric Trucks – Cost of Ownership (2018): NACFE published a guidance report which discusses the total costs of ownership of medium-duty electric trucks and addresses the market, battery technology, regulatory barriers, and the power grid.

TOOLKITS AND MODELLING APPROACHES

EPA Diesel Emissions Quantifier (DEQ): This tool evaluates clean diesel projects and upgrade options for medium-heavy and heavy-heavy duty diesel engines. It helps to estimate emissions benefits and cost-effectiveness for air pollutants and CO_2.

CMAQ Emissions Calculator Toolkit: This tool provides estimated emissions reductions projected from implementing various types of transportation projects eligible under the Congestion Mitigation and Air Quality Program (CMAQ). The toolkit includes modules that model the retrofit and repower/replacement of onroad and nonroad vehicles and equipment.

EPA SmartWay Electrification Resources: This resource includes the Total Cost of Ownership Calculators for Diesel vs. Electric Vehicles.

North American Council for Freight Efficiency (NACFE) Medium-Duty Electric Trucks – Cost of Ownership (2018): NACFE provides an Excel-based

total cost of ownership calculator comparing investment in diesel or gasoline trucks against battery electric alternatives.

California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project Total Cost of Ownership Estimator: This is a tool that provides estimated cost comparisons between zero- and near-zero emission, medium- and heavy-duty buses and trucks of the same sizes with baseline fuels, including gasoline, diesel, and compressed natural gas. Inputs on the availability of grants and incentives can be made to provide an estimate of potential cost reductions for zero and near-zero emission trucks, including electric trucks.

Dana Total Cost of Ownership Calculator (2020): Dana, a drivetrain and electrified propulsion system supplier, provides total cost of ownership calculators for diesel and electric vehicles.

Vehicle Energy Consumption Calculation Tool (VECTO): In the EU, lorry manufacturers are required to monitor and report CO_2 emission and fuel consumption data to the European Commission. The tool can be used to model trucks, buses, and coaches with gross vehicle weights above 3,500 kg (7,716 lb.).

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy.

WORKING WITH COMMUNITIES

U.S. Department of Energy's Clean Cities Coalition Network: This network supports communities in achieving cleaner air and reducing dependence on fossil fuels by promoting alternative transportation options.

FHWA's Zero Deaths and Safe System Program: This program provides resources and guidance to help communities eliminate traffic fatalities and serious injuries. Active transportation is a key component of the Safe System approach, promoting safer streets for pedestrians, cyclists, and motorists.

EPA's Smart Growth: This website provides resources and technical assistance to help communities integrate active transportation into their development plans, promoting compact, walkable neighborhoods.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

IDLE REDUCTION TECHNOLOGIES & STRATEGIES

Idle reduction technologies minimize emissions, enhance efficiency, and improve quality of life for communities and operators by reducing unnecessary engine idling.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural, & Tribal

Idling vehicles and equipment adversely impact air quality, often near densely populated areas, and contribute to greenhouse gas emissions. Idle reduction technology (IRT) refers to devices that enable diesel engine operators to refrain from long-duration idling of the main propulsion engine (referred to as "extended idle") by using an alternative power source. **IRTs can reduce emissions and enhance fuel efficiency by enabling operators to power essential functions without relying on main engines.** In addition, IRT can optimize engine performance in stop-and-go traffic conditions.

Engines are kept idle for a variety of reasons, such as to keep vehicles warm or cool and to power emergency lighting, communications, or off-board equipment. According to Argonne National Laboratory, U.S. passenger cars, light-duty trucks, and medium- and heavy-duty vehicles consume more than 6 billion gallons of diesel fuel and gasoline each year—without movement. About half of this fuel use is attributed to personal vehicles (cars and trucks), which emit about 30 million tons of CO_2 every year just by idling (Argonne National Laboratory, n.d.). In 2019, idling highway vehicles spent nearly 170 billion gallons in gasoline equivalents (Department of Energy, 2019).

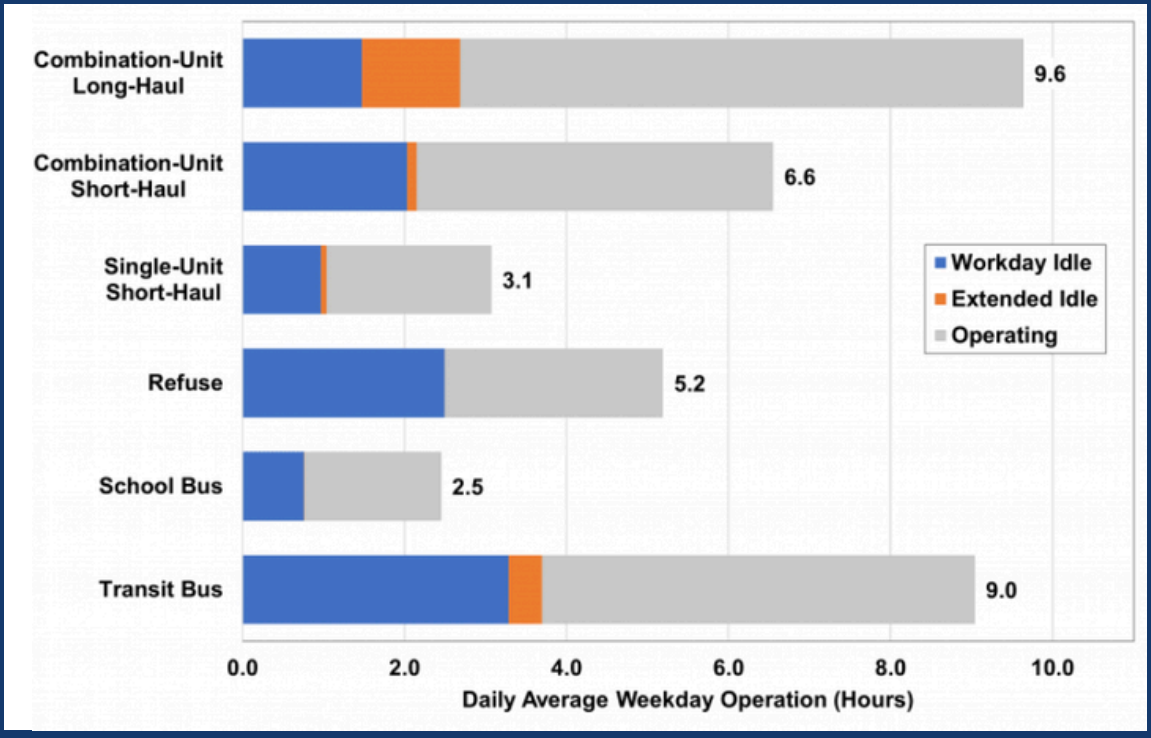
Beyond Technology: Minimizing idling requires a comprehensive approach that extends beyond just technology. Operational strategies involve practices and procedures designed to optimize performance and minimize emissions. These strategies can include:

- Scheduling and Planning
- Regulation and Enforcement
- Innovative Delivery Solutions
- Supply Chain Optimization
- Mode Selection and Overall Efficiency
- Alternative Fuels and Technologies

Read about Freight Operational Strategies, here.

How long do vehicles typically idle?

- **Long-haul trucks** typically idle 6 hours per day, or 1,830 hours per year, but actual practice varies, from idling 1-2 nights per week to hardly ever turning the engine off (Argonne National Laboratory, n.d.).
  - *This equates to 35,570 lbs of CO_2 per year and $5,640 per truck (North American Council for Freight Efficiency, 2019).*
- **Line-haul locomotives** idle for 38% of their operating time, or about 1,650 hours per year (EPA, 2008).
- **Transit buses** idle for an average of 3.7 hours per day (DOE, 2021).
- **School buses** idle 2 hours a day (DOE, February 2015).
- **Police cars** idle about 60% of the time according to a Department of Energy study (DOE, February 2015).
- **Emergency vehicles**, including ambulances and fire trucks, can idle on the scene of fire and medical emergencies or between calls for 30 minutes to an hour or more (Argonne National Laboratory, July 2017).



Average Weekday Operation of Trucks and Buses by Idle Status and Vehicle Type. (Source: DOE, 2021)

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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Examples of IRTs include:

Shorepower

(Also known as cold ironing)
Ships can connect to the local electric grid while berthed, eliminating the need for auxiliary engines and associated emissions.

Auxiliary Power Units (APUs)

Small, independent diesel engines – can power climate control and other on-board systems, reducing reliance on main engines.

These systems are useful for police vehicles, which require power for communications, emergency lighting, and HVAC while stopped.

Electrified Parking Spaces (EPS) / Truck Stop Electrification (TSE)

Dedicated electrical connections at truck stops allow drivers to power essential systems without idling.

Battery Air Conditioning Systems (BACs)

These electric systems provide climate control in parked trucks, enabling drivers to shut off main engines during rest breaks.

Automatic Engine Stop/Start Systems (AESS)

These systems automatically shut down locomotive engines when not in use, significantly reducing idling time.

Because of their effectiveness and relatively low cost, EPA now requires an AESS on all newly-built Tier 3 and Tier 4 locomotives, and on all existing locomotives when they are first remanufactured.

Stop-Start Technology

Conserves energy by shutting off the gasoline engine when the vehicle is at rest, such as at a traffic light, and automatically re-starting it when the driver pushes the gas pedal to go forward.

Stop and Go Traffic: Argonne researchers undertook a series of measurements to determine how long drivers can idle in a queue such as a drive-through before the impacts of idling are greater than they are for restarting the vehicle. They found that fuel use and greenhouse gas emissions are greater for idling longer than 10 seconds. For more information, see the fact sheet, Which Is Greener: Idle, or Stop and Restart?)

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

FREIGHT EMISSIONS IN CONTEXT

In 2019, the three largest ports in the United States in terms of cargo volume processed —the Ports of Los Angeles, Long Beach, and New York and New Jersey— emitted over 2.5 million tons of carbon dioxide equivalents (CO_2e). This estimate includes emissions from ocean-going vessels at port, harbor craft, cargo handling equipment, locomotives, and heavy-duty vehicles (Bertrand and Williams, 2022). At the Port of New York and New Jersey in 2019, on-terminal idling by heavy-duty diesel trucks accounted for 6.6% of CO_2 equivalent emissions port-wide (Park, 2022).

FOCUS ON LONG HAUL TRUCKING

Argonne National Laboratory estimates that rest-period idling by heavy-duty trucks in the U.S. emit about 11 million tons of CO_2 each year. Idling alternatives can result in 95% less fuel use and emissions (Argonne, 2015).

A study by Northeast States Center for a Clean Air Future (NESCCAF) and International Council on Clean Transportation (ICCT) explored various scenarios for reducing heavy-duty vehicle emissions through technology packages that include idle reduction technologies, such as a diesel APU or hybrid system. For example, applying Advanced EPA SmartWay technologies can provide a 28% reduction in CO_2 emissions, while the maximum CO_2 emissions reduction associated with a more aggressive combination package is around 50% (NESCCAF, 2009).

In the National Port Strategy Assessment, EPA estimates that **reducing long-haul truck idle and creep time by 10% reduces CO_2 emissions by 2.6%** (EPA, 2016).

Typical Port Emission Impacts for Each 10% Reduction in Idle/Creep Time, 2020 and 2030.
(*Source: EPA, 2016*)

Strategy	NOx		$PM_{2.5}$		CO_2	
	Tons	Percent	Tons	Percent	Tons	Percent
10% reduction in Idle and Creep time	-22	-2.0%	-2	-2.6%	-8,940	-2.6%

FOCUS ON OCEAN GOING VESSELS

Connecting a ship to the electrical grid while at berth can reduce air pollution from berthed ships by up to 98%. Shore powering one container ship for one day reduces pollution by as much as taking 33,000 cars off the road for a day (Bertrand and Williams, 2022).

An average cruise ship plugging into shore power at Port of Seattle's Terminal 91 saves the greenhouse gas equivalent of a typical car driving 30 road trips from Seattle to New York (Matlock, 2024).

EPA estimates that shore power reduces exhaust emissions during hoteling by 80 to 97% depending upon ship type.

- The technology reduces per call NOx emissions by 62.1 to 89.9%,
- PM emissions by 62.0 to 89.4%,
- exhaust CO_2emissions by 62.3 to 90.9%,
- and well-to-propeller CO_2emissions by 22.4 to 37.6% (EPA, 2016).

According to the EPA's latest Shore Power Technology Assessment at U.S. Ports, 10 ports in the U.S. at the time of this writing are equipped with high-voltage shore power systems There are also planned projects at the ports of Galveston, Miami, and Philadelphia. (EPA, 2022).

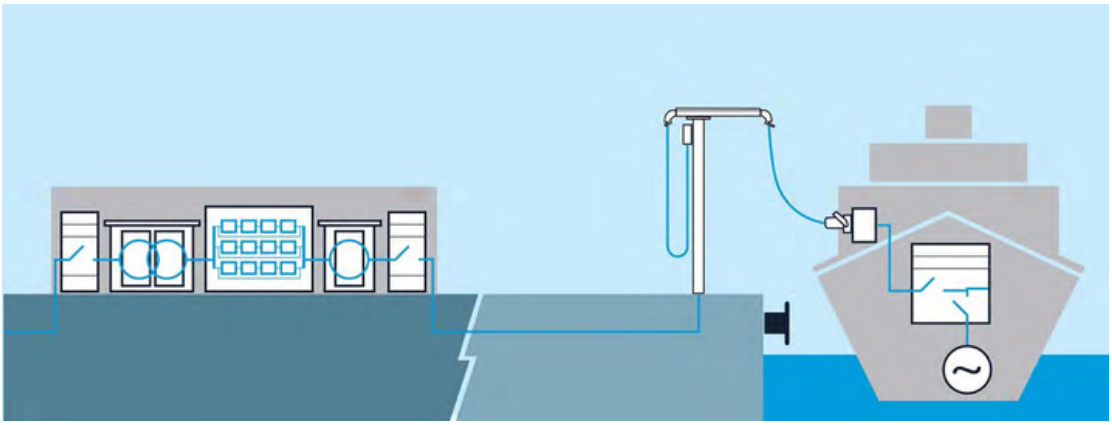

Illustration showing shore power infrastructure, including the electrical substation, cable interface, and ship's electrical equipment.
(*Source: EPA, 2022*)

FOCUS ON LOCOMOTIVES

Automatic Engine Stop-Start (AESS) systems on Tier 2 switcher locomotives can potentially reduce CO_2 emissions by 22 tons per year (EPA, 2016).

The primary idle reduction strategies for locomotives involve replacing or rebuilding older engines to Tier 3 or Tier 4 standards, which includes AESS to reduce idling emissions. For example, replacing a pre-Tier 0 or Tier 0 switcher with a Tier 4 engine would reduce CO_2 emissions by 177 tons per year. AESS can also be installed on older locomotives, resulting in a per locomotive CO_2 emissions reduction of 14 tons per year (EPA, 2016).

Wayside power is being explored to reduce idling emissions at stations. Locomotives and stations can be equipped with electrical infrastructure to allow locomotives to plug into the power grid. This setup allows a train to run air conditioning and lighting without idling the main engine (CARB, 2022).

FOCUS ON PASSENGER VEHICLES

Personal vehicles generate around 30 million tons of CO_2 per year just by idling. Eliminating unnecessary idling of personal vehicles would be the same as taking 5 million vehicles off the roads (DOE, 2015).

Idle stop-start technology can reduce fuel consumption and emissions in city driving by 4 to 10% or more, compared to a vehicle using conventional technology. Over 10 years, this reduction corresponds to fuel cost savings of approximately Can$340 to Can$2,000 and CO_2 reductions of 610 to 3,540 kg per vehicle (Natural Resources Canada, 2014).

Research assessing the effectiveness of anti-idling campaigns near school communities in Salt Lake County, Utah, found a 38% decrease in idling time and 11% decrease in the number of vehicles idling at the school drop-off zones following the campaign (Mendoza et al., 2022).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Reducing engine noise associated with idling can create a safer working environment for port personnel and truck drivers (EPA, n.d.; EPA, 2023).

Reducing engine noise associated with idling can create a safer working environment for port personnel and truck drivers (EPA, n.d.; EPA, 2023).

ACCESSIBILITY AND EQUITY

By reducing emissions from idling equipment, IRTs can contribute to cleaner air for communities often overburdened by health inequities. This can lead to improved public health outcomes and a more equitable distribution of environmental burdens. For resources on community-port collaboration, including toolkits, roadmaps, and primers, visit the EPA Ports Initiative site.

Near-port communities are disproportionately impacted by port operations. For example, nearly all census tracts surrounding the Ports of Los Angeles and Long Beach ranked in the top one-third of the most burdened by pollution in the state. Implementing port projects that reduce air pollution from ships, trucks, and cargo handling equipment can improve health outcomes for sensitive populations (LAO, 2022).

An analysis of 129 ports in the U.S. found that over 20 million people lived within 5 nautical miles of these ports and had a median household income below the 2019 national median. Forty-three (43) of these ports overlapped with lower-income census tracts and areas that do not meet ambient air quality standards (ICCT, 2024).

COST SAVINGS

By minimizing idling time, IRTs allow engines to be shut off during periods of inactivity. This translates directly to lower fuel consumption and maintenance expenses as idling leads to unnecessary engine wear and tear.

A typical long-haul combination truck that eliminates unnecessary idling could save 960 gallons of fuel each year (EPA, 2019).

Considering a railroad that consumes 500 million gallons of diesel fuel annually with 4,000 locomotives, reducing idling time for each locomotive by a conservative 4 hours per day could reduce annual fuel consumption by over 20 million gallons, or 4% of total fuel costs. This equates to $40 million in fuel savings, assuming diesel prices of $2.00 per gallon (Wi-Tronix, 2020).

A European economic analysis of shore power deployments showed net benefit cost ratios ranging from 0.29 (bulk carriers) to 1.64 (container ships). Benefits depend on how shore power is priced and whether monetary incentives are available for shipowners to adopt the technology (Merkel et al., 2023).

AIR QUALITY AND HEALTH

Research suggests idling may contribute up to 34% or more to local air pollution levels (Lee et. al., 2017). By enabling vehicles to power essential functions without relying on idling the main propulsion engine, idling reduction technologies reduce emissions of harmful pollutants and contribute to cleaner air around ports and freight corridors.

Idle reduction technologies can improve in-cab air quality and benefit truck drivers' health. Electrified truck stops provide better in-cab air quality than running the main engine (Lee et al., 2009).

Between 2010 and 2020, Port of New York and New Jersey upgraded 847 trucks to newer diesel engine-year models, or about 30% of the drayage truck fleet, and implemented a maximum idle time of 3 minutes, resulting in an estimated 12.8% reduction in NOx emissions (Park, 2022).

At-berth vessels in the U.S. emitted approximately 27,000 tons of air pollution (nitrogen oxides, sulfur oxides, and particulate matter) in 2019. Prioritizing ports for electrification, including shore power units, can significantly reduce emissions and the amount of pollution that near-port communities are exposed to (ICCT, 2024).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The cost to implement idle reduction technology varies widely depending on the scale, scope, and location of the project.

Switcher Auxiliary Power Unit

Install: $27,000
Technology: $1,400 - $4,100
(EPA, 2019).

Heavy Duty Trucks

Cab Comfort Options for Heavy-Duty Trucks: Fuel Use and Costs.
(Source: DOE, August 2015)

Power Source	**Services**	**Fuel Use (gal/hr)**	**Typical Equipment Cost ($)**
Idling	All	0.6-1.5	NA
Auxiliary Power Unit	All	0.2-0.5	8000-12,000
Diesel-Fired Heater	Heat	0.04-0.08	900-1,500
Heat Recovery	Heat (Limited Duration)	Negligible	600
Storage Cooling	Air Conditioning	0.15	8,500-8,800
Automatic Engine Start/Stop System	All (Intermittent)	0.25	1,500-2,500

Shorepower

Shipside modifications could range from $300,000 to $2 million depending on the type of vessel and amount of retrofitting needed (Wang et al., 2015).

The Port of Oakland allocated $60 million to install shore power infrastructure at their eleven berths on six terminals (Port of Oakland, 2013).

The U.S, Navy, which has used shore power on their ocean-going vessels for many years, estimates that daily electricity consumption for 14 vessels (35,000 kWh) costs $5,000 per day, or $0.146/kWh (EPA, 2022). The EPA maintains a Shore Power Emissions Calculator here with current electricity costs and power plant emission factors, here.

COST EFFECTIVENESS

Using historical vessel call data, researchers identified opportunities for switching vessels to shore power at U.S. ports. Their findings suggest air quality improvements valued at $70-$150 million annually could be achieved by retrofitting a significant portion of vessels. While initial investments in shore power infrastructure would be required, studies indicate this approach could achieve a no net cost scenario over time, with health and environmental benefits balanced by the cost of ship and port retrofits (Vaishnav et al., 2015).

Analysis shows that idling reduction technologies for high-idling trucks (around 2,000 hours per year) become cost-effective within 5 years when fuel costs exceed $2 per gallon. For lower-idling trucks, the payback period lengthens. The upfront cost of various idling reduction technologies (e.g., auxiliary power units, battery air conditioning systems) needs to be factored in (Argonne National Laboratory, 2017a).

FUNDING OPPORTUNITIES

EPA's **Clean Ports Program** provides for investment in clean, zero-emission port equipment and technology; to conduct relevant planning or permitting in connection with the purchase or installation of such equipment or technology; and to help ports develop climate action plans to reduce air pollutants at U.S. ports.

FHWA's **Congestion Mitigation Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The Program provides a flexible funding source for transportation projects and programs to help meet the requirements of the Clean Air Act, including initiatives to reduce idling.

EPA's **Diesel Emissions Reduction Act (DERA) Program** funds grants and rebates that protect human health and improve air quality by reducing harmful emissions from diesel engines.

USDOT's **Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Discretionary Grant program** funds critical infrastructure projects across the country, prioritizing sustainability and equitable access.

USDOT's **Reduction of Truck Emissions at Port Facilities Grant Program** provides funding to reduce truck idling and emissions at ports, including through the advancement of port electrification. The program also includes a study to address how ports and intermodal port transfer facilities would benefit from increased opportunities to reduce emissions at ports, and how emerging technologies and strategies can contribute to reduced emissions from idling trucks.

> Puerto Rico Terminals received funding to buy zero-emission trucks and install charging equipment, which will reduce diesel fuel use within the terminal by nearly 3,000 gallons each year. Learn more about projects **here**.

MARAD's **Port Infrastructure Development Program** funds projects that improve the safety, efficiency, and reliability of moving goods into, out of, around, or within ports.

Idle Reduction Equipment Excise Tax Exemption: Qualified on-board idle reduction devices and advanced insulation are exempt from the federal excise tax imposed on the retail sale of heavy-duty highway trucks and trailers. The exemption also applies to the installation of qualified equipment on vehicles after the vehicles have been placed into service.

COMPLEMENTARY STRATEGIES

Idling reduction technologies can complement other operational improvements like traffic management systems and optimized scheduling to further streamline port operations and reduce overall environmental impacts.

Upgrading existing engines with cleaner technology or transitioning to zero-emission alternatives like electric trucks or hydrogen-powered cargo handling equipment, alongside IRTs, can significantly improve air quality and contribute to achieving ambitious climate goals.

Idle reduction strategies can be applied to the various modes of transportation involved in intermodal freight, such as trucks, trains, and ships, during loading, unloading, or waiting times. By optimizing processes and using technology like automated scheduling or real-time tracking, intermodal freight operators can reduce idle times, improving overall efficiency and GHG reductions.

View All Strategies

CASE STUDIES

SAVING FUEL IN NEW JERSEY THROUGH TRUCK STOP ELECTRIFICATION

18
Truck Stop Electrification Spaces

227 T
Metric Tons Emissions Saved

19,000
Gallons of Diesel Fuel Saved

Source: New Jersey Clean Cities Coalition

Long-haul truck drivers typically idle their vehicles during mandated rest periods to maintain access to air conditioning, heat, and electricity. The Flying J Travel Plaza in Carneys Point, New Jersey has 18 truck stop electrification spaces that provide trucks with heading and air conditioning, electricity, cable TV, and internet, allowing truckers to use these auxiliary systems without idling. In 2018, the use of the site represented 227 metric tons of mitigated emissions, and nearly 19,000 gallons of diesel fuel savings.

IDLE REDUCTION FOR EMERGENCY VEHICLES

Fire engines and trucks idle on the scene of fire and medical emergencies from 30 minutes to an hour or more. All fire departments in the Argonne study used diesel auxiliary power units, which draw fuel from the main tank, to reduce idling. Like battery auxiliary power units, diesel auxiliary power units power a vehicle's electrical load when the vehicle engine is off. Diesel auxiliary power units use about 80% less fuel than idling the engine and can provide nearly uninterrupted power for long periods. These auxiliary power units displaced 700 to 1,000 idling hours (saving $1,750 to $2,500 at a fuel cost of $2.50/gallon) per vehicle each year. Because of the reduced engine-on time, the system reduces maintenance costs with fewer oil changes and engine repairs.

MISSOULA RAILYARD LINK

8
APUs

95%
Reduction in annual NOx

$2.1 M
Net Savings

During colder weather months line-haul and switcher locomotives located in the Missoula Railyard Link ran and idled continuously to prevent engine freezing. The net idling emission reductions due to the yard idling policy change and auxiliary power unit installation that were done in 2010 are noted below:

- 95% reduction in annual NO_x emissions
- 89% reduction in annual PM emissions
- 60% reduction in in annual CO emissions

Annual fuels savings averaged $235,964 due to the reduced fuel use of the APUs and the implemented idling policy. The APUs and their installation were paid for by cost savings in under two years. The expected lifetime of the APU units is 10 years, so the net savings in fuel costs after purchase and installation of the eight APUs over the ten-year period will be approximately $2,115,642.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT'S WAREHOUSE ACTIONS AND INVESTMENTS TO REDUCE EMISSIONS (WAIRE) PROGRAM

The California South Coast Air Quality Management District (SCAQMD) enacted an Indirect Source Rule regulating indirect warehouse emissions in 2021. The Warehouse Indirect Source Rule was developed to reduce air pollution from mobile sources such as trucks delivering goods to and from the facilities, yard trucks, transport refrigeration units, ships, and trains. The Warehouse Indirect Source Rule operates using a points-based system. The program requires operators to earn a certain number of points each year to offset the annual number of truck trips made to and from the warehouse, with larger trucks such as tractors or tractor-trailers multiplied by two and a half. Points needed to offset vehicle emissions can be earned by implementing projects from a menu (such as EV charging infrastructure) or by paying a mitigation fee, which funds incentives for near-zero and zero-emission trucks and zero-emission charging and fueling infrastructure in communities near warehouses.

IMPLEMENTING IDLE REDUCTION TECHNOLOGIES & STRATEGIES: **WHAT TO READ NEXT**

Many idling reduction technologies like automatic engine start-stop systems for locomotives or battery air conditioning systems for heavy-duty trucks are based on well-established technologies. This translates to relatively simple installation and integration with existing equipment.

Shore power technology offers a significant long-term opportunity for ports to achieve substantial emission reductions. The maritime industry is taking a proactive approach by investing in shore power infrastructure solutions. Standardization efforts are underway to ensure seamless compatibility between ports and vessels, further accelerating adoption. Additionally, innovative financing models and public-private partnerships are being explored to make these investments even more attractive.

Read about California Air Resources Board's (CARB) At-Berth Regulations, here.

Enacting **anti-idling regulations or time limits** can be a readily implementable strategy for various sectors. These regulations are often already established around schools, hospitals, and other sensitive areas, providing a familiar framework for broader adoption.

Some jurisdictions have laws against idling, including:

- New York City
- Massachusetts
- Maryland
- New Hampshire
- New Jersey
- Vermont
- Hawaii
- Parts of California, Colorado, New York, Ohio, Utah, and other states

Check Clean Cities' IdleBase for a list of local and state regulations to see whether your area has laws that restrict idling.

Sample Idle Reduction Policy and Policy Guidance

Sustainable Environment for Quality of Life hosts a Sample School Bus Anti-Idling Policy online. The policy, as well as other action steps are detailed, here.

RESOURCES

GENERAL RESOURCES

EPA Ports Initiative: This initiative works with U.S. ports and local communities to improve environmental performance. The program provides technical resources, such as guides on creating port emission inventories, and toolkits and resources to promote community-port collaboration. The Ports Initiative is currently running pilot projects at four ports to provide technical assistance for community collaboration.

DOE Energy Efficiency and Renewable Energy, Idle Reduction: This resource introduces idle reduction practices, their benefits, and resources for personal and commercial vehicles.

EPA Smart Way Idling Reduction Technologies (IRTs): This resource highlights EPA's SmartWay program, which verifies and promotes clean and efficient technologies, including verified IRTs for reducing emissions from idling trucks.

EPA Best Clean Air Practices for Port Operations: This resource offers best practices for ports to reduce air pollution, potentially including strategies to minimize idling times from ships and cargo handling equipment.

North American Council for Freight Efficiency, Idle Reduction: This webpage details different idle reduction technologies, and their associated benefits and challenges.

EPA Idle-Free Schools Toolkit for a Healthy School Environment: This resource provides guidance and tools for schools to implement idle-free zones around school grounds, protecting children from harmful air pollution.

TOOLKITS AND MODELLING APPROACHES

DOE Office of Energy and Efficiency & Renewable Energy, IdleBox: A Toolkit for Idle Reduction Education and Outreach: This toolkit synthesizes resources for engaging and educating stakeholders and community on idle reduction, and how to start a campaign.

Federal Highway Administration, Congestion Mitigation Air Quality Improvement (CMAQ) Emissions Calculator Toolkit, Diesel Idle Reduction Strategies: This tool provides air quality benefit calculations for diesel idle reduction strategies.

EPA Diesel Emissions Quantifier (DEQ): This tool allows users to estimate air pollutant emissions from various sources, including idling diesel vehicles.

Argonne National Laboratory, Vehicle Idle Reduction Savings Worksheet: This downloadable spreadsheet helps calculate potential fuel cost savings associated with reducing vehicle idling times.

DOE Petroleum Reduction Planning Tool: This online tool helps assess strategies and opportunities for reducing petroleum use across different sectors, including potential benefits from reducing vehicle idling.

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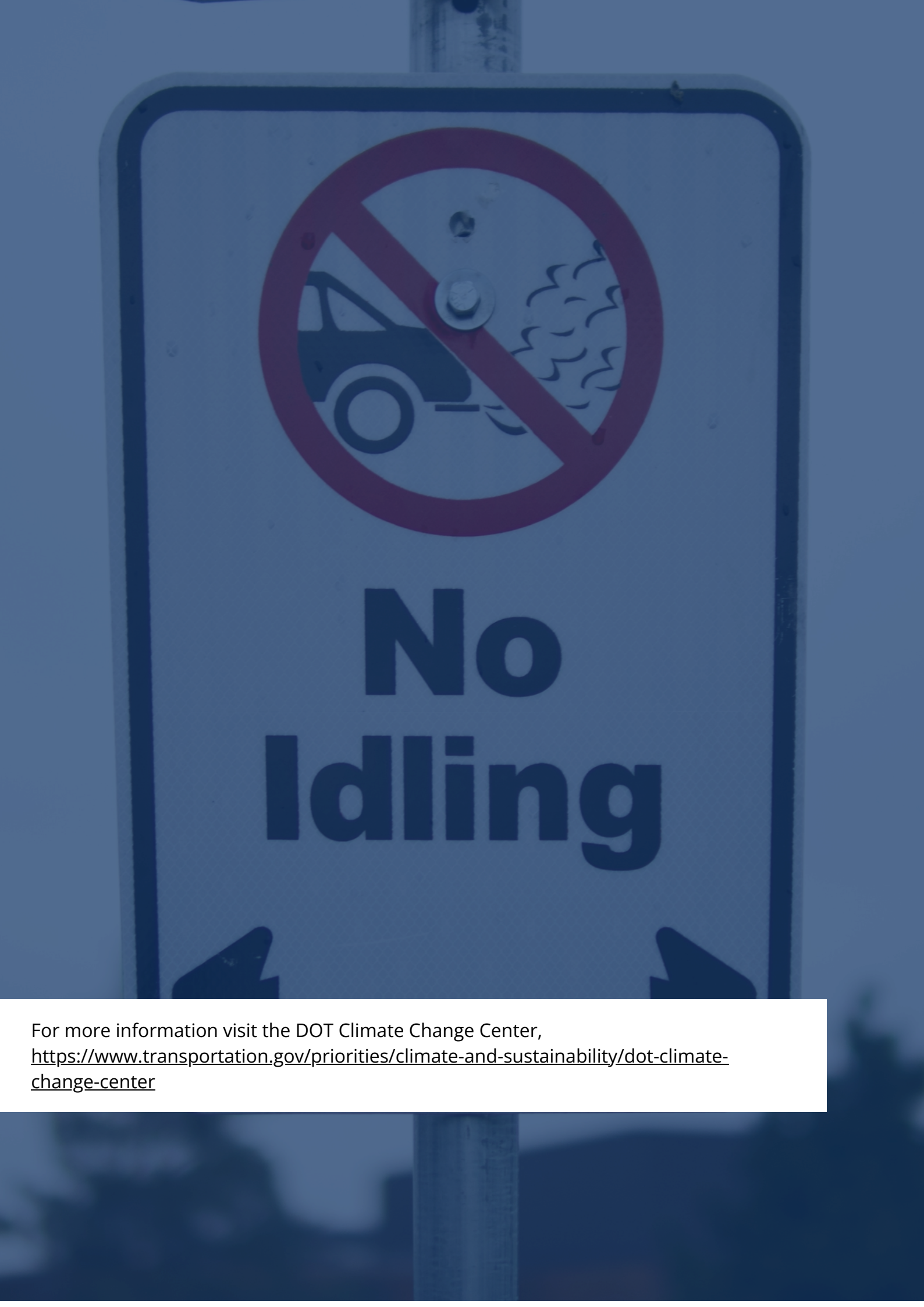

For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

IMPROVED TRAVEL DEMAND MODELING

Improved travel modeling enables more accurate accounting of changes in travel behavior and associated greenhouse gas emissions, which leads to transportation infrastructure investment decisions that are more fiscally responsible, alleviate long-term traffic congestion, and align with climate goals.

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OVERVIEW

Best Suited for:
Long Term
Urban & Suburban

While increasing roadway capacity by adding lanes may reduce congestion in the short term, highway infrastructure capacity expansions typically increase demand in the long term. Accurate travel demand modelling is better able to capture demand for vehicle miles that is induced by expanded roadway capacity and limited alternative transportation options like pedestrian routes and public transit service. **Induced vehicle miles traveled (VMT) can increase greenhouse gas (GHG) emissions, worsen air quality, reduce safety, increase noise pollution, and create less livable communities for families and businesses near expansion projects.** Furthermore, these projects may not alleviate the highway congestion that they are intended to reduce. In other words, a road is likely to fill up long before its due for reconstruction.

Did you know?

In Walkable City, author and planner Jeff Speck reports on a meta-analysis of studies that found "on average, a 10% increase in lanes miles induces an immediate 4% increase in vehicle miles traveled, which climbs to 10%—the entire new capacity—in a few years."

Many commonly used travel demand models, such as traditional "four-step" models, face challenges in accounting for the full range of changes in travel behavior and land use that may result from additional roadway capacity. Changes include the decentralization of land use patterns, greater generation of auto trips, increases in trip distances, and decreased use of transit and nonmotorized modes. These models also may have limited sensitivity to projects and strategies that promote alternatives to driving, such as bike and pedestrian facilities.

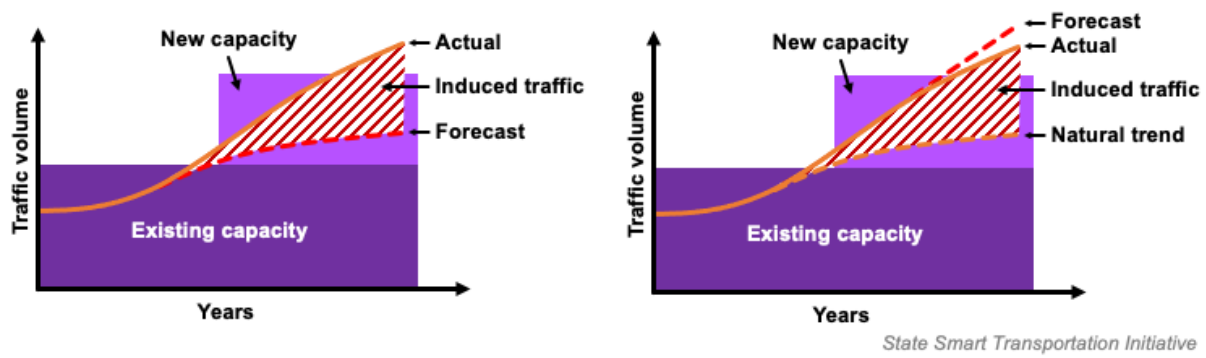
Defining Induced Vehicle Travel

Induced vehicle travel refers to the rise in demand for travel demonstrated by additional vehicle miles travelled that occur in response to an increase in roadway supply. Induced travel demand follows basic economic principles – as the cost of driving does down, the quantity of driving goes up. Any initial increases in travel speeds are temporary, and traffic-related air pollution and greenhouse gas emissions ultimately increase as a result of adding new lanes. **Building additional roadway capacity induces more vehicle travel** (Volker & Handy, 2023). Learn more about induced vehicle travel at the UC Davis National Center for Sustainable Transportation.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

Activity-based models, which use dynamic traffic assignment, and integrated transportation land use models can better capture traveler behavior as it changes in response to existing and changing conditions. These tools better account for many changes in travel behavior and can provide better information to decisionmakers, helping prioritize projects that have a higher potential for meeting local and regional goals such as reducing GHG emissions by encouraging use of transit and alternative transportation modes. See the Best Practices section for five key approaches to improve the accuracy of travel demand forecasts.

> *Meta-analyses of numerous studies show that a 10% increase in metropolitan lane miles induces an almost immediate 3-6% increase in VMT, which climbs to 6-10%–the entire new capacity–in the following five to ten years (Speck, 2012; Handy and Boarnet, 2014).*



Common depiction of induced vehicle travel (left) versus case with aggressive traffic forecast (right) (Source: State Smart Transportation Initiative)

Travel demand modelling can be used in a variety of project types, including:

- Changes in capacity
- Changes in pricing schemes (including, tolls, congestion pricing, fare structure, parking pricing)
- Changes in land-use
- Improvements to existing infrastructure

Travel demand modelling can inform many decisions, including:

- Scale and scope of projects
- Route planning
- Station locations
- Service frequencies
- Pricing strategies

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

IGNORING INDUCED TRAFFIC EXAGGERATES THE BENEFITS OF CAPACITY EXPANSIONS

Research shows that highway expansion projects are often pursued for short-term congestion relief and that environmental analyses required by federal and state law do not always account for induced travel effects (Lee, 2023; Volker and Sinetos, 2021).

UC Davis researchers reviewed five highway expansion projects approved in California and found that only three projects' environmental reviews estimated induced travel effects. Analyses conducted for these three projects failed to accurately analyze induced vehicle travel and greatly over-estimated the congestion and GHG benefits of highway expansion (Volker, Lee, and Handy, 2021).

Litman (2024) provides examples and case studies showing what happens when induced vehicle travel is not factored into analysis for capacity expansion projects. In one example where two lanes are added to a four-lane highway, if generated traffic is ignored in travel demand modeling, traffic will grow at a steady 2% per year. When generated traffic is considered, modeling predicts much faster growth until maximum lane capacity is reached after about 9 years. There is a difference of over 1,000 trips per peak hour on the expanded roadway when induced travel is included in modeling (Litman 2024).

CAPACITY EXPANSION PROJECTS DRIVE INCREASES IN VMT AND EMISSIONS

Roadway capacity projects that add lane miles can significantly drive up VMT. For example, the Rocky Mountain Institute estimates that traffic generally increases by a range of 2 to 8 million VMT per year for every new highway lane mile added in Colorado's urbanized areas. More densely populated areas with busier roads tend to fall on the upper end of the range (Rowland, 2021). Improved travel demand modeling could help prioritize projects that address roadway congestion issues without dramatic increases in VMT and associated emissions.

There is about a 1:1 ratio in percent change in GHG emissions to percent change in VMT. Increasing the number of lane miles, and therefore increasing VMT for a given roadway by – say 25% - would therefore increase GHG emissions by about 25% as well (CS, 2009).

Volker and Handy (2023) reviewed 12 studies related to induced travel and found clear linkages between highway capacity expansion and VMT. Roadway capacity expansions of 10% are likely to increase VMT by 3 to 8% in the short term and 8 to 10% or more in the longer term.

The full impacts of new or extended lanes on VMT across a road network are typically seen within 3 to 10 years. Reasons for VMT increase include (Volker & Handy, 2023):

- People may shift from other modes to driving.
- Drivers may make longer or more frequent trips.
- In the longer term, people may move farther away from where they work, or take jobs farther away from home.

CLIMATE-SMART SOLUTIONS TO ROADWAY EXPANSIONS

Roadway expansions may reduce congestion and per-mile emission rates in the short-term but are likely to increase total emissions in the longer term. The lowest vehicle emission rates are typically seen at 20 to 50 miles per hour (mph). Adding lanes may initially reduce extreme congestion (Levels of Service [LOS] E or F) and associated emissions, but these benefits are typically small and offset by speeds above 50 mph and induced VMT (Litman, 2024).

Investing in high-quality public transportation, road pricing programs, and commuter benefits can provide greater emissions reductions compared with capacity expansions (Litman, 2024).

Influence on highway policy largely rests at the local level. Comprehensive research into the effects of capacity expansions found that new auto capacity made up a significant share of planned and programmed funding in all California regions (as of 2023). Highway expansions were primarily designed to support new auto-oriented land development. Local policies that support active transportation and multimodal investments can help reverse these spending patterns (Lee, 2023).

The Convenient Transportation Action Plan, developed by the U.S. Department of Transportation, Department of Energy, Environmental Protection Agency, and Department of Housing and Urban Development, was released in December 2024. The plan emphasizes prioritizing fixing and modernizing existing assets, rather than expanding road infrastructure (e.g., widening highways), to enable a more convenient and fiscally responsible transportation system. Examples of fiscally responsible transportation investments include:

- Active Transportation projects, including new bicycle and pedestrian infrastructure. *See the Active Transportation Strategy Guide.*
- Transit-oriented development to support more walkable and dense communities with better access to transit services. *See the Transit-Oriented Devolvement Strategy Guide.*
- Retrofitting highways to reconnect communities, creating space for transit or active transportation.
- Adding grade separations at train crossings to prevent lengthy detours and vehicle idling while trains are passing.
- Fixing existing assets, like bridges, to prevent drivers from making detours and adding unnecessary miles to vehicle trips.
- Congestion pricing and parking pricing to reduce congestion and encourage lower carbon-intensity travel modes. *See the Road Pricing Strategy Guide.*

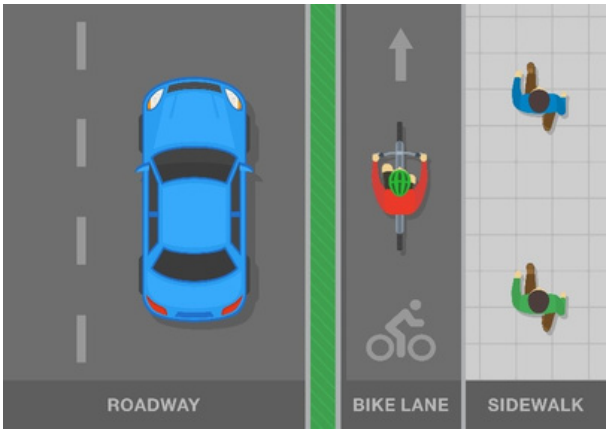
CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Travel demand modeling can inform better decisions for reducing VMT and support the development of complete streets, providing a safer environment for pedestrians and bicyclists and decreasing opportunities for vehicle-pedestrian and vehicle-bicycle crashes. Safety improvements, in turn, positively reinforce uptake of low-emission modes (Boutros et al., 2023).

Focusing on highway maintenance and retrofitting over continual expansion can make roads safer for all road users. For example, a post-project evaluation of a highway removal project in Rochester, New York found that the project increased walking by 50 percent and biking by 60% (McCormick, 2020).



AIR QUALITY AND HEALTH

Capacity expansions increase traffic-related air pollution in the medium- to long-term. Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways (USEPA, 2014; Jbaily et al., 2022).

Improved travel demand modeling supports transportation agencies and planners in prioritizing fiscally responsible transportation infrastructure projects that reduce congestion, reduce greenhouse gas emissions from individual trips, and decrease air pollutants that are harmful to human health (Litman, 2024).

Modeling the effects of generated traffic can show how adding lanes increases air pollution. Post-project data from a capacity expansion on I-405 in Los Angeles show increased air pollution and limited congestion relief (Planetizen, n.d.).

COST SAVINGS

Longer and induced vehicle trips can lead to more automobile dependent transportation and land use over the long term. These costs are difficult to quantify but are likely significant. Improved travel demand modeling helps account for additional vehicle trips and vehicle miles travelled that would be generated (or induced) by expanded highway capacity and any associated limited access to other options, like pedestrian street-level routes or public transit service. Limiting transportation options to trips available by car, or incentivizing longer car trips, may increase household transportation costs to include car ownership, car maintenance, gas costs, and parking fees (Litman, 2024).

Instead of adding capacity, transportation can be repriced in an equitable manner by converting fixed costs (like insurance premiums and vehicle registration fees) to variable costs that are charged on a per-mile basis. A FHWA study found that bundling six different repricing strategies could reduce vehicle miles traveled by 32 percent and save low-income drivers $460 per year (Viggiano, et al., 2024).

ECONOMIC GROWTH

Accurately accounting for induced vehicle travel from new highway capacity expansion and other transportation infrastructure projects enables transportation agencies to prioritize funding for projects that meet demand and enable economic growth and community vitality (Litman, 2024).

Research has shown that public transit and active transportation projects produce more jobs per dollar than road infrastructure projects (Smart Growth America, 2010; Peltier, 2011). Active transportation projects can also spur economic development and generate revenue to cover the relatively minimal maintenance costs of the active transportation network (WeConservePA).

RURAL

Induced vehicle travel occurs in rural areas too. Any time a project increases average travel speeds, makes travel times more reliable, makes driving perceptibly safer or less stressful, or opens up access to new areas, VMT increases (Volker & Handy, 2023).

According to the National Bridge Inventory, average detour miles for rural travelers is nearly twice as much as detours by urban travelers. Fixing bridges in rural areas to prevent unnecessary detours can lead to a significant reduction in miles traveled for both passengers and goods and reduce air pollution in near-highway communities (BTS Rural).

RESILIENCE AND ADAPTATION

Highway capacity expansions can trigger land use and land growth effects that reduce the resilience of regions and communities to climate change. In one study that used remote sensing technology to analyze the impacts of highway capacity expansion in California on land use and land cover (LULC), researchers found that expansion projects, particularly those located near less-developed areas with more extensive natural vegetation, can cause significant habitat and vegetation loss (Alexander et al., 2023). This vegetation loss, along with the increase in impervious surfaces that naturally comes with highway development, can increase flood risk during storms and have wide-reaching effects on ecosystems and biodiversity (Massachusetts Climate Action Tool).

COST CONSIDERATIONS

COST EFFECTIVENESS

Travel demand modeling can be cost-effective in the long run by helping policymakers anticipate and plan for infrastructure needs and potentially reducing unnecessary spending on projects that may exacerbate congestion. Better modelling enables more efficient allocation of resources and helps avoid costly overruns by accounting for future demand shifts (Litman, 2024).

COST OF IMPLEMENTATION

The cost of updating a travel demand model and incorporating new planning and travel demand forecasting processes can vary widely depending on factors such as the scope and complexity of the model, the availability and quality of data, and the need for external technical input. The benefits of accurate modeling outweigh these initial costs through more efficient infrastructure planning and investment decisions.

See the Convenient Transportation Action Plan for information about fiscally responsible transportation investments.

FUNDING OPPORTUNITIES

FHWA's **Prioritization Process Pilot Program** (PPPP) funds the development and implementation of pilot prioritization processes that address and integrate the components of existing transportation programs and support projects that improve safety, climate change and sustainability, equity, and economic strength and global competitiveness consistent with DOT's strategic goals. The PPPP supports data-driven approaches to planning, which may include modeling the impacts of highway expansion projects.

OST-R Research Opportunities: OST-R coordinates the Department's research investment, oversees the development of Annual Modal Research Plans, and provides opportunities for research collaboration with public and private sector partners. For example, DOT invests in the future of transportation through its University Transportation Centers (UTC) Program, which awards and administers grants to consortia of colleges and universities across the United States. The UTC Program advances the state-of-the-art in transportation research and technology, and develops the next generation of transportation professionals. The Congressionally-mandated program has been in place since 1987 to help address our Nation's ever-growing need for the safe, efficient, and environmentally sound movement of people and goods.

COMPLEMENTARY STRATEGIES

Travel demand modelling can be used to support policymakers in transportation infrastructure project prioritization and may lead to deprioritizing certain highway capacity expansion projects that cause, rather than alleviate, highway traffic congestion. Providing safe and accessible active transportation infrastructure can serve as an alternative transportation funding priority and can support community access to low-carbon alternatives to driving reducing reliance on personal vehicles, particularly for short-distance trips. This information can help guide the allocation of resources to maximize the benefits of these projects.

Travel demand modeling can be used to support policymakers in transportation infrastructure project prioritization and may lead to deprioritizing certain highway capacity expansion projects that cause, rather than alleviate, highway traffic congestion. Providing safe and accessible public transit infrastructure, including bus rapid transit, can serve as an alternative transportation funding priority and can support community access to low-carbon alternatives to driving reducing reliance on personal vehicles, particularly for short-distance trips. This information can help guide the allocation of resources to maximize the benefits of these projects.

Travel demand modeling can be used to support policymakers in transportation infrastructure project prioritization and may lead to deprioritizing certain highway capacity expansion projects that fail to alleviate highway traffic congestion in the long term. Providing safe and accessible public transit infrastructure can serve as an alternative transportation funding priority and can support community access to low-carbon alternatives to driving reducing reliance on personal vehicles, particularly for short-distance trips. This information can help guide the allocation of resources to maximize the benefits of these projects.

Travel demand modeling plays a critical role in assessing the effects of road pricing on transportation systems. By analyzing how pricing schemes influence travel behavior, transportation planners can anticipate changes in travel demand elasticity and sensitivity to changes in price. This analysis helps design effective congestion mitigation strategies.

View All Strategies

CASE STUDIES

EMPIRICAL ESTIMATES OF INDUCED TRAVEL ELASTICITIES FROM AREA-WIDE STUDIES

Volker and Handy (2022) reviewed 12 studies that estimated an elasticity of (vehicle miles traveled) VMT (or vehicle kilometers traveled, VKT) with respect to lane miles. In the U.S., short-run elasticity estimates range from 0.07-0.76, while longer-run elasticity estimates range from 0.26-1.06. Excluding studies that included local roads, which tend to have the lowest VMT density of all road types and provide the least per-mile improvement in travel speed or access, the range of elasticities shrinks to 0.23-0.76 (short-run) and 0.77-1.06 (long-run). This research was used to support an update to the elasticities used in the Induced Travel Calculator, which allows users to estimate VMT induced as a result of lane additions in California.

What is elasticity?

- Elasticity is the percentage increased in VMT that results from a 1% increase in lane miles. An elasticity of 1.0 means that VVMT will increase proportionally with lane miles.
- Short-run elasticities captured induced VMT effects that occur immediately and within the first 1-3 years after a capacity expansion, such as substituting driving for other modes.
- Long-run elasticities capture a broader range of induced travel effects that occur after 3 to 10 years, including persistent short-run effects and changes in land use.

INDUCED VMT FROM CALIFORNIA HIGHWAY EXPANSION PROJECTS

Researchers applied the California Induced Travel Calculator to five highway expansion projects approved in California between 2009 and 2021 and found that for the three projects that estimated induced travel effects, all three estimates were lower (two were more than 10 times lower) than Calculator estimates. The use of improved travel demand modeling can provide decisionmakers and the public with more accurate estimates of induced travel effects and added traffic, air pollution and GHG emissions.

IMPLEMENTING IMPROVED TRAVEL DEMAND MODELING: **WHAT TO READ NEXT**

There are several ongoing efforts that can help State DOTs, MPOs and local governments implement travel demand modeling. USDOT is required by the Bipartisan Infrastructure Law (PL 117-58 Sec. 11205. Travel Demand and Data Modeling) consider the historical accuracy of travel demand modelling and support States and MPOs in increased travel demand modelling accuracy efforts. The Transportation Research Board is also actively pursuing research to develop an Induced Demand Assessment Framework and a guide for DOTs to apply the assessment framework to policy and planning analysis.

Check out these resources to learn more about highway expansion policy and the importance of accounting for induced travel in environmental analyses:

- Increasing Highway Capacity Induces More Auto Travel (Volker and Handy, 2023).
- The Policy and Politics of Highway Expansions (Lee, 2023).
- Generated Traffic and Induced Travel (Litman, 2024).

BEST PRACTICES FOR TRAVEL DEMAND MODELING ACCURACY

This section provides best practices for travel demand forecasting based on review of the literature and consultation with academic experts in the field (Volker and Handy, 2022; Volker et al. 2021; Mladenovic and Trifunovic, 2014; Marshall, 2018). Improved and updated models provide more accurate assessment of future travel demand when prioritizing investments in transportation infrastructure projects.

- **Account for Historical Accuracy:** Travel demand modelling should account for historical accuracy of projections. In cases where systematic biases or inaccuracies are identified via comparisons to historical projections, models should be adjusted to compensate for these shortcomings.
- **Account for National Studies:** Many studies assert that long-term travel demand elasticity associated with new lane miles is consistently around 1.0. This means that highway travel demand tends to rise to fill new capacity over time, reducing the congestion relief of highway capacity expansion projects, while negatively impacting regional air quality through induced vehicle miles traveled. Project environmental and other analyses should incorporate best-in-class research and analysis on travel demand.
    - This analysis applies to urban and suburban areas, but the research is developing for the impact of highway capacity expansion projects in rural areas outside of metropolitan statistical areas and Metropolitan Planning Organization areas.
- **Disclose Model Considerations:** In order to foster robust engagement and promote government transparency, travel demand modelling and project prioritization processes (including State Transportation Improvement Plans) should clearly and simply disclose the limitations of the travel demand model with respect to measurement of induced travel and land use growth effects.
- **Intervene Early in Planning Phase:** Accounting for induced vehicle travel and the possibility of little or no roadway congestion relief in the planning and environmental review processes is critical to understanding the costs and benefits of highway expansion projects and other transportation investments. USDOT recommends that state and local decisionmakers account for induced travel during the Planning Phase using the best available research on elasticities of vehicle miles travel relative to lane mile.

- **Consider Congestion Mitigation Strategies:** Strategies that mitigate congestion need to be taken into consideration including innovative technology solutions, traffic efficiency improvements, cordon and congestion pricing, as well as conversion of general-purpose lanes to high occupancy vehicle lanes or high occupancy toll lanes can mitigate congestion (see the Transit Cooperative Research Program Report 95). These strategies, alongside fast, reliable, and affordable transit, improvements to cycling and pedestrian networks, and compact development have the potential to reduce vehicle miles traveled and support equitable transportation access.

RESOURCES

GENERAL RESOURCES

Transportation Research Board Critical Issues in Transportation for 2024 and Beyond: Research in Progress – Induced Demand Assessment Framework: A Guide: This guide presents local agencies and departments of transportation with an assessment framework on induced demand, including defining induced demand, presenting data needed to develop assessments, piloting and testing the framework, and communicating findings to build consensus.

Transportation Research Board National Cooperative Highway Research Program Traffic Forecasting Accuracy Assessment Research: This report develops a process and methods to analyze and improve the accuracy, reliability, and utility of project-level traffic forecasts.

Closing the Induced Vehicle Travel Gap between Research and Practice and The Policy and Politics of Highway Expansions: These two academic papers consider the gap between academic documentation of induced travel effects and the practices of transportation agencies in accounting for travel demand.

The Massachusetts Climate Action Tool allows users to access information on climate change impacts and vulnerability of species and habitats, as well as explore adaptation strategies and actions to help maintain healthy, resilient natural communities based on location and interests.

Check out these resources to learn more about highway expansion policy and the importance of accounting for induced travel in environmental analyses:

- Increasing Highway Capacity Induces More Auto Travel (Volker and Handy, 2023).
- The Policy and Politics of Highway Expansions (Lee, 2023).
- Generated Traffic and Induced Travel (Litman, 2024).

TOOLKITS AND MODELLING APPROACHES

The National Center for Sustainable Transportation (NCST) developed the California Induced Travel Calculator, which allows users to estimate induced vehicle miles traveled (VMT) from highway capacity expansion projects. As induced VMT is often not accurately accounted for when evaluating transportation projects, this calculator offers a simple way to estimate induced VMT for a more complete understanding of the impacts on travel demand. This helps to accurately analyze whether the congestion benefits of a project might be outweighed by the potential induced VMT to select projects that will have high decarbonization potential. However, a study evaluating the application of the Induced Travel Calculator for rural projects found that the tool consistently overestimated VMT growth. This further demonstrates the need to better understand demand elasticity.

Rocky Mountain Institute (RMI) in coordination with Transportation for America, the National Resources Defense Council, and a consortium of other partners to create the State Highway Induced Frequency of Travel (SHIFT) Calculator, which draws on formulas sourced from decades of proven scientific literature to deliver detailed, community-specific induced vehicle travel forecasts with the click of a button. RMI's tool makes it easy to estimate induced vehicle travel, relative to how many new lanes miles are built in a given city.

Colorado DOT (CDOT) uses an advanced state-wide activity-based model (ABM) to estimate travel demand. As an ABM, CDOT's model derives travel from each person's choice of daily activities, providing a realistic depiction of changes in people travel behavior as travel conditions change. This and other features permit CDOT's statewide model to support sensitivity to "induced demand," much better than older model forms.

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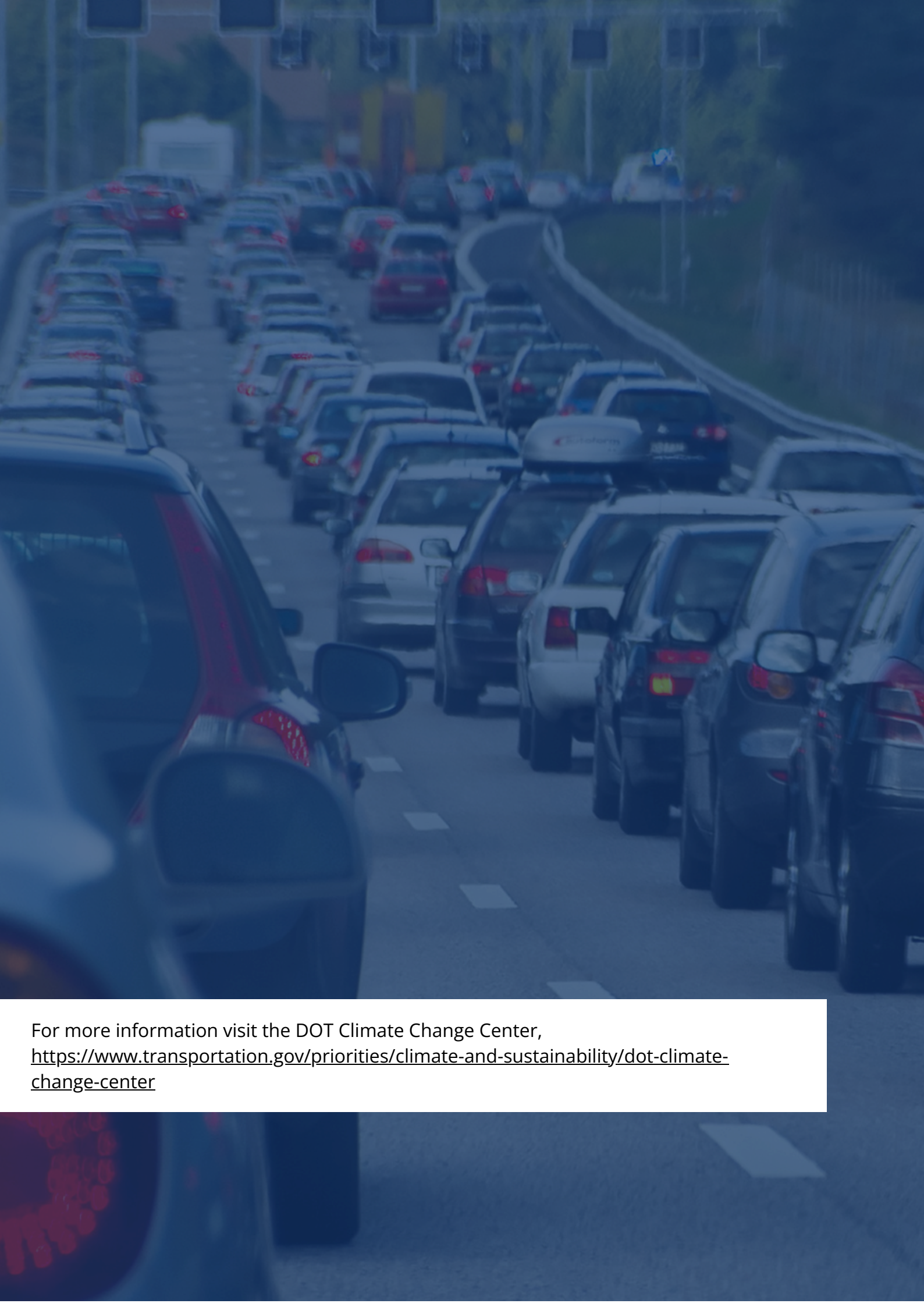
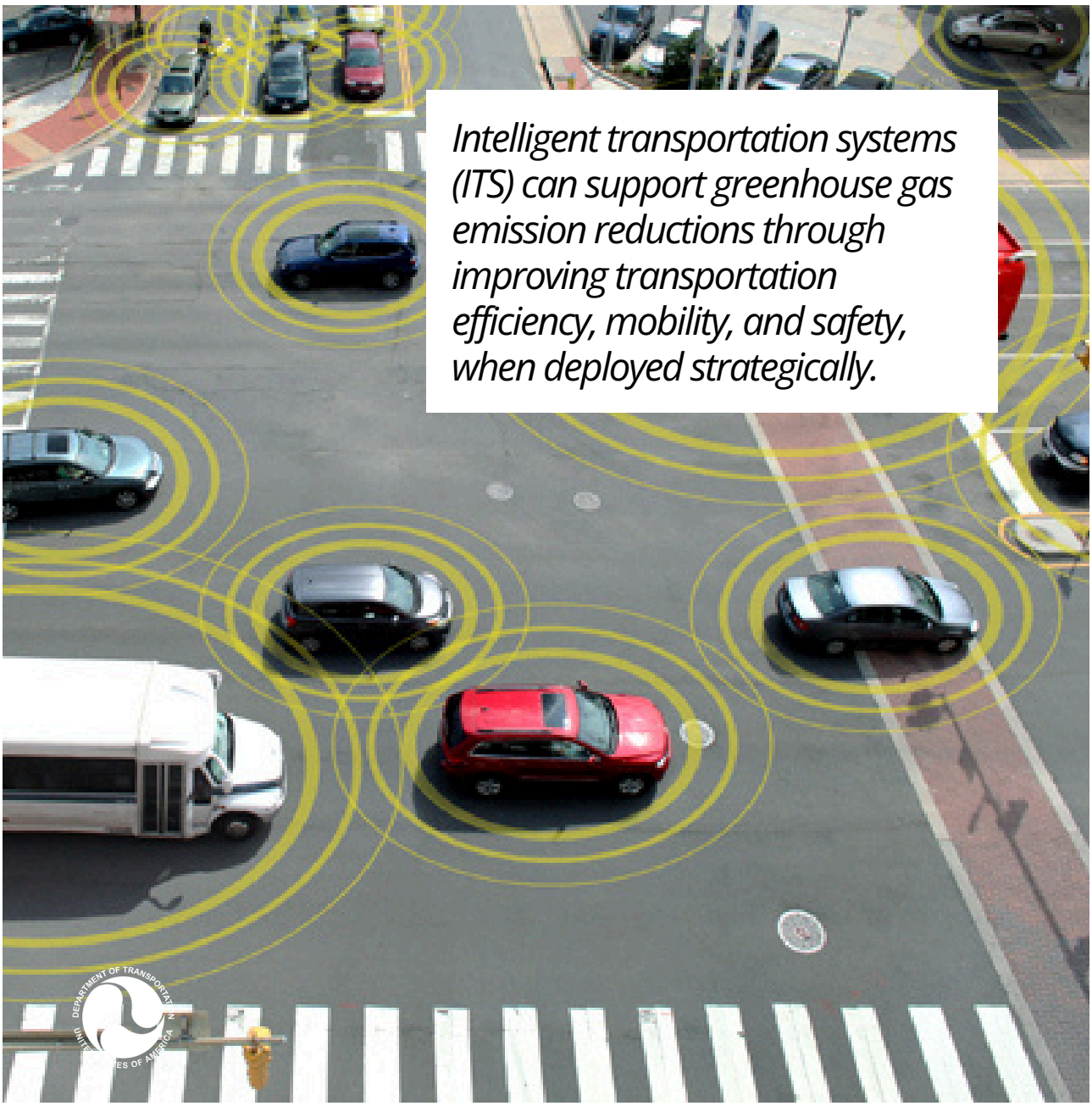


For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

INTELLIGENT TRANSPORTATION SYSTEMS



Intelligent transportation systems (ITS) can support greenhouse gas emission reductions through improving transportation efficiency, mobility, and safety, when deployed strategically.

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OVERVIEW

Best Suited for:
Long Term
Urban, Suburban, Rural & Tribal

ITS technologies, including connected vehicles (CV) and vehicle-to-everything (V2X) technologies, **can improve transportation system efficiency, mobility, and safety by integrating advanced information and communications-based technologies into transportation infrastructure and vehicles.** Examples of ITS technologies include adaptive signal control, forward collision warning, signal preemption and priority for transit and emergency vehicles, queue warning, work zone safety warnings, vulnerable road user signal crossing applications, and more. Additionally, **ITS data can be used in real time to inform operators and travelers on roadway conditions, safety issues, and overall performance of the transportation network.**

Applied strategically, ITS technologies can facilitate both direct and indirect reductions in greenhouse gas emissions. ITS technologies, particularly when applied synergistically across a region or along a corridor, can reduce congestion, reduce the number of crashes, and reduce stop-and-go behavior and idling, which can in turn reduce overall emissions and improve local air quality.

Did you know?

Smart charging, in which networked charging stations monitor and restrict charging based on real-time demand and grid conditions, can reduce cumulative emissions from electric vehicles by over 30% compared to conventional charging (Jenn and Brown, 2021).

ITS applications make the use of lower carbon modes more efficient (for example, by using transit signal priority) and improve safety for pedestrians, bicyclists, and other vulnerable road users. By improving the safety and convenience of lower carbon modes, ITS technologies may, over time, contribute to increased use of these modes, resulting in reductions in overall transportation greenhouse gas (GHG) emissions in the longer term.

ITS technologies have cross-cutting benefits (Source: ITS JPO).

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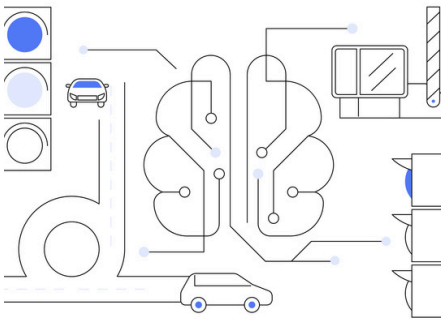
See summaries of select ITS technologies:

Vehicle-to-everything (V2X) technology enables vehicles to communicate with each other, with road users such as pedestrians and cyclists, and with roadside infrastructure. V2X communication types include: vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P). In the National V2X Deployment Plan (August 2024), USDOT established to deploy V2X on 20% of the National Highway System by 2026, 50% by 2029, and full deployment by 2034. The National V2X Deployment Plan also establishes goals for V2X deployment at signalized intersections, with 85% of intersections in the top 75 metro areas being V2X enabled by 2034.

Overall, V2X safety applications can reduce up to 16% of CO_2 emissions and eco-routing driving applications in individual vehicles can reduce emissions by close to 10% (TNO, 2020).

Adaptive signal control technologies (ASCT) and signal priority systems can reduce travel delays, increase average speeds, and reduce emissions along busy corridors. ASCT and signal priority systems collect real-time demand data, which can be used for optimization of signal timing in response to traffic conditions. Implementing ITS technology at signalized intersections can increase efficiency and reduce delays to motorists and pedestrians. ASCT and signal priority systems can improve the efficiency of the transportation system as the variability and unpredictability of traffic demand on arterial systems often outpace the ability of local and State agencies to update signal timings. ASCT and signal priority systems have demonstrated emission reductions in several deployments across the country through improved traffic flow. (FHWA, 2018; Ban et al., 2014; Dutta et al., 2008; Hutton et al., 2010; Cambridge Systematics, 2016).



Eco-approach and departure at signalized intersections allow drivers to adapt their speed to pass the intersection or stop in the most eco-friendly manner. The GlidePath prototype application, which is a cooperative adaptive cruise control system that uses V2I communications, allows a traffic signal to communicate wirelessly with an equipped vehicle. In comparison to speed recommendations using a driver-vehicle interface incorporated into the speedometer, the V2I GlidePath application provides a 15% reduction in fuel use by minimizing the lag in speed

changes and maintaining an optimal speed and approach (ITS JPO, 2016).

Complete streets and shared street uses can adopt ITS technologies to improve safety for vulnerable road users, including pedestrians and cyclists. For example, sensors and signage mounted at intersections can allow for safer vehicle-cyclist interactions, and crosswalks retrofitted with sensors can warn transit buses and trucks when a pedestrian is crossing their intended path. Trucks can be retrofitted with bicyclist/pedestrian detection systems and collision early-warning systems. Adaptable, smart infrastructure, such as intelligent lighting and on-demand conversion of right-of-way for pedestrians and after-school play zones, can promote more equitable land use and incentivize use of lower carbon modes (ITS JPO, 2020).

Variable message signs (VMS) and variable speed limits (VSL) can be used to reduce congestion and manage speeds during inclement weather, traffic accidents, and other roadway conditions. VSL can dynamically manage speeds during planned (peak-hour congestion) and unplanned (incidents) circumstances, while VMS are electronic roadside signs that inform drivers of incidents, special events, and other useful travel information. Both VMS and VSL can help smooth the drive-cycle and reduce idling emissions (FHWA, 2020; MDOT, 2022).

Work zone management leverages ITS technologies to better manage roadway work zones, which often contribute to reductions in roadway capacity and changes in roadway/lane configurations, causing congestion and safety hazards. ITS technologies can be used to communicate with drivers in and around roadway work zones by providing real-time traveler information, recommendations for speed limit adjustments, and audio- and image-based in-vehicle messages to provide drivers with early warnings about road conditions and status. Work zone management can improve safety by preventing crashes and decrease emissions from vehicles passing through work zones by limiting congestion (Li et al., 2018; FHWA, 2014).

Curb management and smart parking technologies can reduce idling time for goods delivery, food delivery, and ridesharing vehicles, and can decrease distance traveled to locate parking. Scheduling applications can also enable curbside and parking reservations and management by replacing a “first-come-first-served” system with the ability to proactively reserve curb and parking space and thereby reduce circling, idling, and double parking (ITS America, 2023). See the *Digital Freight Solutions and Emerging Technologies* page for more information about the potential climate and safety benefits of curb management strategies.

SMART Grants Reduce Emissions through V2X Technology

The Strengthening Mobility and Revolutionizing Transportation (SMART) grant program, established by the Bipartisan Infrastructure Law, funds demonstration projects focused on advanced smart community technologies and systems that improve transportation efficiency and safety. Several SMART projects are applying V2X technology to reduce vehicle emissions and improve safety for road users:

- The City of Colorado Springs is installing radar, lidar, video, and weather/counting stations to enhance detection of all road users (vehicles, pedestrians, cyclists). This deployment will improve safety and efficiency, making traffic flow more responsive to current road conditions and reducing the likelihood of accidents.
- The Orange County Transportation Authority (OCTA) is developing a signalized intersection prototype along Harbor Boulevard, a multimodal corridor that accounts for 8% of all OCTA bus ridership. The prototype will deploy nine signalized intersections with transit signal priority and detection technology. The prototype will improve transportation access by reducing travel times, reduce GHG emissions by minimizing bus idling and stopping, and increase the safety of vulnerable road users through detection technology.

For additional examples, see ITS JPO: Energy & Environment benefits.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

ITS PROJECTS PROVIDE FUEL SAVINGS AND EMISSIONS BENEFITS

Smart Cities and V2X: The Dallas Smart Cities Living Lab pilot implemented several V2X elements, including pedestrian sensors, smart parking, and smart lighting. In addition to increasing foot traffic by 13% year-on-year, the living lab blocks saw a 35% decrease in energy use due to Intelligent LED lighting and an estimated 7-10% decrease in CO_2 emissions associated with cruising for parking (Trey et al., 2018).

Cellular V2X: An initial deployment of cellular-V2X for signal priority in Fulton County, Georgia school buses proved that fuel savings of more than 10% can be expected. The same study also showed decreases in travel time of 13% and a 40% decrease in the number of unplanned stops along bus routes (North Fulton Transportation, 2022).

In-Vehicle Advisories: A study evaluating audio- and image-based in-vehicle warning messages in work zones showed a 16.4% reduction in CO_2 emissions from vehicles passing through the work zone (Li et al., 2018).

Eco-Driving: A traffic microsimulation was used to determine the impacts of cooperative eco-driving (CED) systems on signalized corridors in Riverside, CA. The CED system is expected to reduce energy consumption by 7% and pollutant emissions by up to 59% compared to conventional vehicles (Wang et al., 2019).

Intelligent Intersections: FHWA summarized evaluation data for intelligent intersection signal controls including eco-approach and departure and found that coordinating signals and eco-driving systems (e.g., cooperative adaptive cruise control) provide fuel savings of up to 12-13% (FHWA, 2014).

Smart Charging: Smart charging involves a network of charging stations that optimize energy usage by monitoring and restricting charging based on power grid demand and condition. A 2021 study by UC Davis's Institute of Transportation Studies found that smart charging can reduce cumulative emissions from EVs by over 30% compared to conventional charging (Jenn and Brown, 2021).

Parking Price Management: The San Francisco Municipal Transportation Agency led the SFpark Pricing Pilot demand-based pricing parking management system. Parking prices varied based on the occupancy rate of the parking area, which led parking users to park in areas where there was more availability, spending less time in high-demand areas. The total time to find an available parking spot decreased by 43%, traffic volume decreased by 8%, and GHG emissions decreased by 30% in the pilot areas (SFMTA, 2021).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

The Safe System Approach supports zero deaths on roadways through Safe Roads, Safe Vehicles, Safe Road Users, Safe Speeds, and Post-Crash Care. ITS can play a role in each element, saving lives. For example, thermal cameras track pedestrians in real time and improve safety for vulnerable road users (FHWA, 2024).

The National Highway Traffic Safety Administration (NHTSA) noted that the implementation of just two V2X safety applications, Intersection Movement Assist (IMA) and Left Turn Assist (LTA), would prevent 439,000 to 615,000 crashes, 13% to 18% of the total, and save 987 to 1,366 lives. The resulting savings from these reduced crashes would be $55 to $74 billion (ITS America, 2023).

When vehicles are turning into the path of a pedestrian or bicyclist, communications between vehicles and vulnerable road users, such as beacon systems and Bicycle/Pedestrian-to-Vehicle alerts, could potentially avoid 97% of crashes (Qian et al., 2022).

Utah DOT is installing LiDAR sensors to detect pedestrian movements at intersections. The sensors could allow UDOT to adjust signal timing in real time and potentially integrate with cellular vehicle to everything (C-V2X) technology to broadcast pedestrian locations to vehicles approaching an intersection or initiating a turn (Li et al., 2023).

Advanced driver assistance systems (ADAS), including forward collision warning, automatic emergency braking, and lane centering assistance, have the potential to save thousands of lives annually. A large-scale analysis of police crash and vehicle equipment data from 13 states showed the ADAS reduced serious front-to-rear crashes by 42% (Ronne et al., 2022).

A variable speed limit system along a 15-mile section of I-95 in Virginia reduced fatal and serious crashes by 13% (Cho et al., 2023).

COST SAVINGS

There are significant cost savings associated with V2X deployments, including costs related to reductions in

fuel use, air pollution, delay time, incidents, injuries, and fatalities.

At the Port of Virginia, truck reservation systems using RFID tags and real-time information from a cloud-based system is expected to reduce truck trip time by 51 minutes (66%) due to reduced queuing and idling, saving trucking companies over $2.7 million in fuel costs (Port of Virginia, 2017).

Intersection conflict warning systems installed at 93 unsignalized rural intersections in Minnesota, Missouri, and North Carolina had estimated benefit-cost rations of 16 to 39 as a result of significant decreases in crashes, fatalities, and injuries (Himes et al., 2016).

ECONOMIC GROWTH

V2X technologies have the potential to bring safety and economic benefits to the transportation network. For example, NHTSA estimates that safety applications enabled by V2X technologies could eliminate or mitigate the severity of up to 80% of non-impaired crashes, or nearly 37,000 fatalities, 3 million injuries, and $800 million in damages (USDOT, 2016).

ACCESSIBILITY AND EQUITY

The Accessible Transportation Technologies Research Initiative (ATTRI) focuses on research to improve the independent mobility of travelers with disabilities through the use of ITS and other advanced technologies. ITS technologies can help track transportation system user's movements, infer map information, and use sensor data to create routes and provide information in audible, tactile, and haptic communication formats (Giampapa et al., 2017).

USDOT's ITS4US Deployment program is focused on solving mobility challenges for all travelers, with a specific focus on underserved communities. For example, the Complete Trip Deployment in Buffalo, NY will improve mobility within and around the Buffalo Niagara Medical Campus by deploying technologies such as an accessible trip planning tool, community-based on-demand shuttles, and intersection pedestrian safety technologies. Learn more about this deployment and other ITS4US initiatives here.

AIR QUALITY AND HEALTH

V2X technologies can help smooth the drive cycle and reduce frequent accelerations, decelerations, and idling, which in turn reduces emissions (TNO, 2020). V2X deployments may be particularly beneficial in port regions with poor air quality and along congested freight corridors.

A study evaluating audio- and image-based in-vehicle warning messages in

work zones showed considerable reductions in air pollutants, including a 19% reduction in NOx emissions and 16% reduction in CO emissions (Li et al., 2018).

RURAL COMMUNITIES

Infrastructure for pedestrians in rural areas may be limited; V2X technologies can improve safety and walkability. For example, rectangular rapid flashing beacons (RRFBs) were installed at crosswalks in small and rural communities in Vermont in 2021. When the RRFBs were active, drivers were 2.6 times more likely to yield to pedestrians and pedestrian wait time was not significantly impacted (Rowangould et al., 2023).

COST CONSIDERATIONS

The ITS JPO maintains a Costs Database with cost estimates for ITS deployments. Cost data can be used to develop project cost estimates during the planning or preliminary design phases. Both capital and operating & maintenance costs are provided where possible.

Maryland DOT installed and tested roadside units at a single intersection to evaluate crosswalk safety. The dual-mode units had two communication capabilities: dedicated short-range communication (DSRC) and cellular-vehicle to everything (C-V2X). The total project cost, including one year of maintenance was $84,000 (Maryland DOT, 2023).

Connected vehicle technology was deployed on school buses in Fulton County, CA for approximately $5,000 per bus and $5,000 per intersection. These costs covered connected-V2X technology and allowed for traffic signal priority (Descant, 2022).

The estimated costs for implementing adaptive signal control systems on 3,280 intersections in the Twin Cities metro area (Minnesota) was approximately $70 million or $21,300 per intersection (University of Minnesota, 2021).

The Utah Autonomous Shuttle Pilot provided passenger service at eight locations across Utah over a 17-month project period in 2019. The shuttle was a Level 4 (High Driving Automation) vehicle that could operate at 8-11 mph on fixed, repeated routes. The shuttle cost $400,000 to lease and operate, with an additional $227,000 in UDOT staff time and engineering support (WSP/UDOT, 2021).

FUNDING OPPORTUNITIES

Strengthening Mobility and Revolutionizing Transportation (SMART): This USDOT grant program funds demonstration projects focused on advanced smart community technologies and systems that improve transportation efficiency and safety. Eligible projects include connected vehicles, aviation innovation, smart grid, and traffic signal innovation.

Safe Streets and Roads for All (SS4A) Grant Program: USDOT's SS4A program was established by BIL to support regional, local, and Tribal initiatives to prevent roadway deaths and serious injuries through the safe system approach. Similar to the Zero Deaths and Safe System Program, safety improvements from SS4A will encourage mode choice by removing safety barriers to active transportation.

Clean Ports Program: This EPA program provides for investment in clean, zero emission port equipment and technology; to conduct relevant planning or permitting in connection with the purchase or installation of such equipment or technology; and to help ports develop climate action plans to reduce air pollutants at U.S. ports. Funding may be used for ITS deployments that support zero emission technology and infrastructure.

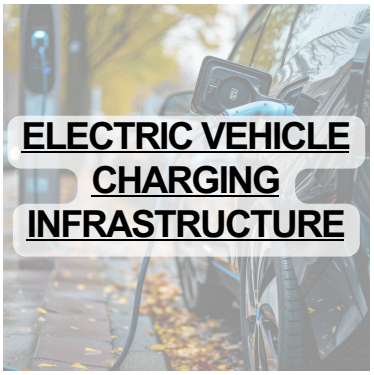
Truck Emissions at Port Facilities (RTEPF) Grant Program: FHWA's RTEPF program provides funding to test, evaluate, and deploy projects that reduce port-related emissions from idling trucks. Eligible projects include port electrification and efficiency improvements, focusing on heavy-duty commercial vehicles, and other related projects.

Exploratory Advanced Research (EAR) Program is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. FHWA's EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

Congestion Mitigation and Air Quality Improvement (CMAQ) Program: FHWA's CMAQ program supports surface transportation projects and other related efforts that contribute to air quality improvements and provide congestion relief. CMAQ-eligible projects include V2X technologies such as adaptive traffic control systems, electronic and open road tolling, and variable speed limit/variable message signs.

Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN):
FHWA's ATTIMD and ATTAIN programs support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance V2X include integrated corridor management systems, electronic pricing and payment systems, and retrofitting DSRC technology deployed as part of an existing pilot program to C-V2X technology.

COMPLEMENTARY STRATEGIES



Smart charging systems using V2X technology to monitor, manage, and restrict the use of charging devices to optimize power grid conditions and battery health.

CAV and V2X technologies are seeing increased applications in freight transport, from drone delivery to various curb management strategies.

Cargo bikes, small autonomous vehicles, and other micromobility devices may use V2X technology to improve the efficiency and safety of deliveries. Technology can be installed on devices, cellular phones, and roadside.

V2X technology can support parking reforms through data collection to better predict parking demand and Smart Parking systems.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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V2X technology enables implementation of road usage charges, including congestion pricing and cordon pricing programs. In-vehicle transponders communicate with overhead gantries and data collected from roadside monitors can be use to adjust tolls depending on traffic conditions.

V2X can enable monitoring and management of travel demand for shared micromobility devices. Safety features can also allow vehicles to communicate directly with scooters and bikes, for example, by warning them of an approaching or turning vehicle.

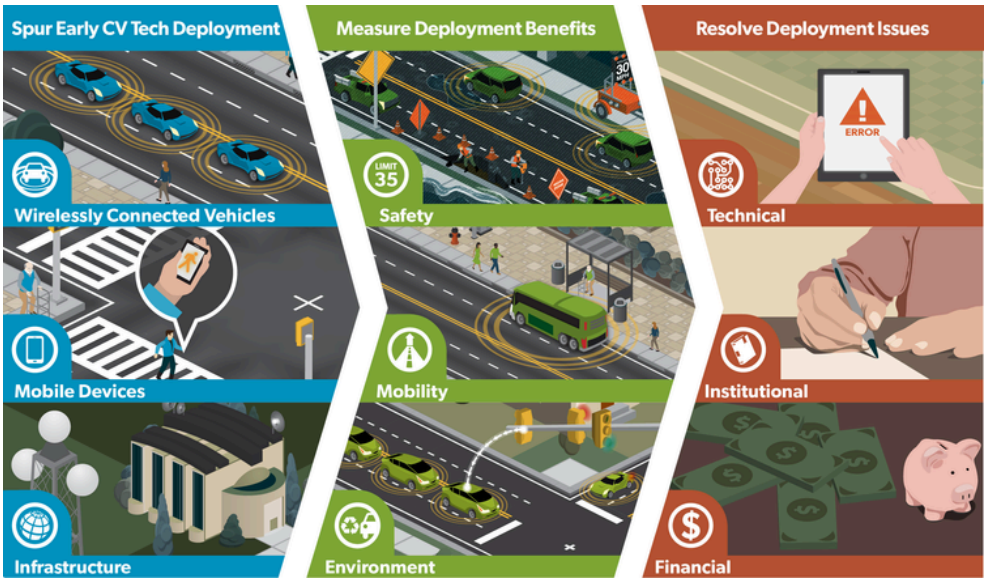
Eco-driving, cooperative adaptive cruise control, and other V2X technologies contribute to improved energy efficiency. They can be installed in any vehicles, from small passenger vehicles up to the largest Class 8 trucks.

View All Strategies

CASE STUDIES

NEW YORK CITY DOT (NYCDOT) CONNECTED VEHICLE PILOT

NYCDOT led a CV deployment in 2021 with the aim of improving the safety of travelers and aligning with the city's Vision Zero initiative to reduce the number of fatalities and injuries due to traffic crashes. The pilot involved a fleet of approximately 3,000 CVs, installing 470 roadside units at signalized intersections, along a major thoroughfare (FDR Drive), and at other strategic locations, and pushing in-vehicle pedestrian warnings. Although improving safety was the primary objective of the NYC pilot, simulations showed that reducing crashes in the deployment area also decreased crash-related congestion, fuel consumption, and GHG emissions.



(Source: NYCDOT)

SCHOOL BUS SIGNAL PRIORITY IN FULTON COUNTY

A pilot study conducted in Alpharetta, GA equipped school buses with cellular connected-vehicle technology and installed CV-enabled roadside units at 62 signalized intersections along the school bus routes. These technologies provided transit signal priority to buses as they approached each traffic signal. Results of the pilot showed a 13.3% decrease in travel time and 7.4% and 12.4% decreases in fuel consumption for a propane bus and diesel bus, respectively.

TEXAS: CARBON REDUCTION STRATEGY V2I TECHNOLOGY

The Texas Carbon Reduction Strategy includes the installation of vehicle-to-infrastructure (V2I) technology on key freight corridors to improve communication and traffic flow along the highway network. The technology upgrade aims to improve the safety and efficiency of current systems and support strategies related to reduced transportation emissions.

IMPLEMENTING INTELLIGENT TRANSPORTATION SYSTEMS: **WHAT TO READ NEXT**

ITS JPO Resources: The USDOT's ITS Joint Program Office supports development and implementation of ITS. The ITS JPO maintains an extensive database with benefits, costs, and lessons learned from over 3000 ITS deployments across the country, including findings related to safety, efficiency, mobility, and environmental benefits. For more information, see the ITS Deployment Evaluation website, detailed Benefit Data, and Benefits and Costs Map.

V2X Deployment Plan: Successfully developing and deploying V2X technologies requires close coordination across USDOT, state and local governments, and Tribes, researchers, OEMS, automotive suppliers, transit and freight operators, communication providers, and standards development organizations, among others. See USDOT's National V2X Deployment Plan for more information.

V2X Community Stakeholder Groups (Source USDOT).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

V2X connectivity is envisioned as a cooperative system where technology operates as a single system despite various stakeholders, owners, operators, and equipment. Achieving interoperability requires close coordination across government and industry. The USDOT's standards and architecture includes the National ITS Reference Architecture, a resource that provides a framework for safe, secure, and effective interoperable systems (USDOT 2023).

Adaptive Signals: At a high level, adaptive signals require planning, equipment, maintenance, and technical skills. Before implementing adaptive signals, agencies should use the FHWA's Systems Engineering Process for ASCT Systems to identify needs and requirements and determine if adaptive signals are appropriate. For more information, see FHWA's ASCT Resources and WSDOT's Resources on Adaptive Signals – Coordination, Integration, and Timing.

RESOURCES

GENERAL RESOURCES

USDOT ITS Joint Program Office. Since its formation in 1994, the ITS JPO has led collaborative research to support the development and implementation of ITS. The JPO maintains a library of resources to support ITS demonstrations, ITS Deployment Evaluations, Benefits, and Costs, ITS CodeHub, and ITS DataHub.

WSDOT TSMO Resources. Washington State DOT (WSDOT) has developed an interactive website for transportation professionals to learn more about Transportation Systems Management and Operations (TSMO). Strategies include CAV, ITS, and transportation demand management with ratings based on cost, technology, and level of collaboration required.

Saving Energy with Connectivity. In collaboration with USDOT, DOE announced a Notice of Intent for a FY24 Funding Opportunity Announcement for Saving Energy with Connectivity. Projects will develop and deploy approaches using vehicle-to-everything (V2X) high-speed, low latency communication to improve the efficiency and convenience of the mobility-system. Projects could include but are not limited to eco-driving along connected corridors, transit priority, intermodal optimization, or freight priority. Projects under this program will culminate in the deployment of hardware in real-world settings, serving as a model for future deployment.

Cooperative Driving Automation.

- FHWA's CARMA Program is leading research on cooperative driving automation (CDA) which would enable communication and cooperation between properly equipped vehicles and infrastructure.
- DOE also supports CDA research through research funding through the ARPA-E NEXTCAR Program and research funding for New Mobility Systems. DOE's portfolio of work includes defining and developing communication requirements to implement energy centric CDA applications, including information messages exchanged, required communication latency, frequency, bandwidth, and other state-of-the-art requirements as well as evaluate their impacts on energy efficiency over a range of scenarios. DOE's CDA research includes optimizing the signal phase and timing of traffic signals and connected vehicle/connected and automated vehicle (CV/CAV) trajectory planning along multi-intersection arterials and highways.

Smart Community Resource Center. The SCRC, maintained by USDOT and ITS JPO, is designed to connect States, Tribal governments, and local communities with resources that can be used to develop intelligent transportation systems and smart community transportation programs. It is a comprehensive central resource for ITS-related information.

ITS JPO's ITS Standards Program. Established by USDOT in 1996, the ITS Standards Program helps encourage widespread use of ITS technologies. To date, 99 standards have been published and are ready for use in ITS deployments, such as Dynamic Message Signs and Connected Intersections.

Architecture Reference for Cooperative and Intelligent Transportation (ARC-ITS). ACR-IT provides a common framework for planning, defining, and integrating intelligent transportation systems. It is a mature product that reflects the contributions of a broad cross-section of the ITS community. Service packages address specific services like traffic signal control and provide a straightforward entry into ARC-IT content.

USDOT's Safety Band Website. This site provides many resources related to the radio spectrum (5.9 GHz) reserved for transportation safety. These resources include an interactive map showing CV deployment locations across the country and state-by-state crash data that could potentially be mitigated through deployment of Safety Band technology.

FHWA's Planning and Implementing Multimodal, Integrated Corridor Management: Guidebook. Integrated Corridor Management (ICM) is an operational concept that seeks to reduce congestion and improve performance by maximizing the use of available multimodal capacity across a corridor, including highways, arterial roads, and transit systems. The NCHRP Web-Only Document 287: Planning and Implementing Multimodal, Integrated Corridor Management: Guidebook provides an overview of current recommended practices and outlines critical components for the planning, design and development, and operations and maintenance of an ICM system.

TOOLKITS AND MODELING APPROACHES

FHWA's Congestion Mitigation and Air Quality Improvement Program (CMAQ) Emissions Calculator Toolkit: The CMAQ Toolkit includes a tools specifically designed to estimate the air quality and greenhouse gas reduction benefits of V2X projects, including Adaptive Traffic Control Systems, Travel Advisories, Electronic and Open Road Tolling.

DOE's Energy Efficiency Mobility Systems: The EEMS Program supports the DOE Vehicle Technology Office's mission to improve transportation energy efficiency through low-cost, secure, and clean energy technologies. The SMART Mobility 2.0 Laboratory Consortium supports a range of research on advanced mobility solutions, including CAV, curb management, and micromobility.

DOE's POLARIS: This tool allows for advanced travel and freight demand modeling and simulations for multi-modal systems. It can be used to analyze transportation systems involving CAV and V2I technologies and conduct systems level optimization on parameters including travel time and energy usage.

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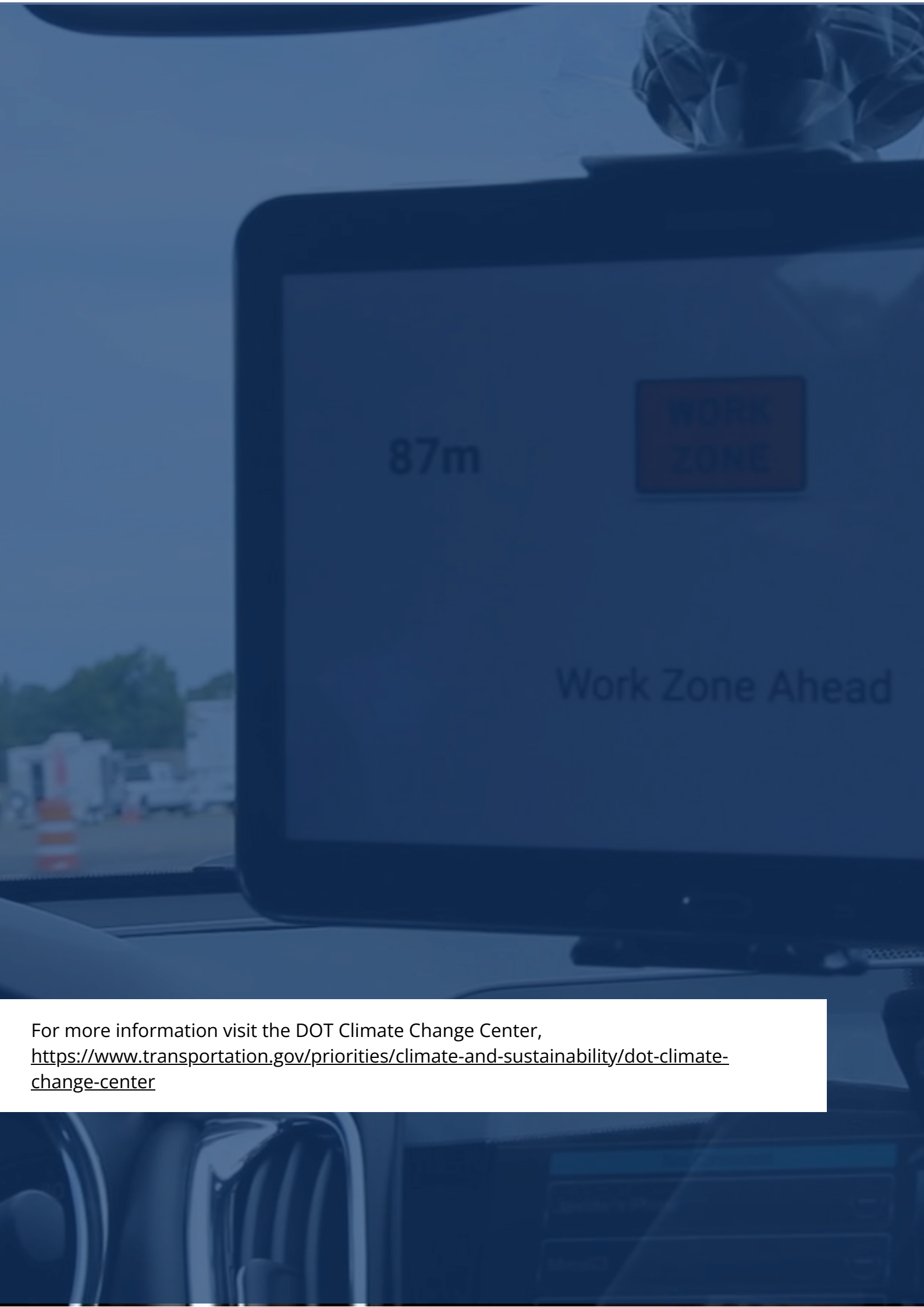

For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

INTERCITY BUS

Intercity buses bridge critical transportation gaps in rural areas, between urban centers, and during high traffic periods, by offering sustainable, accessible, and convenient travel options.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Intercity buses provide sustainable and convenient travel options for a diverse range of journeys and contexts. Intercity bus routes may connect major cities as a longer haul public transportation option or may serve rural communities that have otherwise limited to no public transportation networks. The national intercity bus network is extensive, with over 1,800 carriers operating nearly 28,000 buses, according to the American Bus Association Foundation. The intercity network has seen significant growth over the last two decades, with scheduled trips reaching nearly 5,000 every weekday – a 35% increase since 2006. This translates to **an annual ridership of 62 million passengers,** which can be compared to the 650 million served by commercial airlines each year (American Bus Association, 2022).

Bus routes are significantly cheaper and quicker to establish and implement than other forms of public transit and are also highly flexible, responsive to changing travel patterns and passenger demand. On a per-passenger basis, particularly for journeys between 200 and 500 miles, **bus travel has much lower greenhouse gas emissions per trip than single-occupancy vehicles and air travel**. For example, a comparative analysis shows that travelling from St. Louis to Chicago (approximately 300 miles) by bus emits one-fifth the CO_2 of travelling in a single-occupancy vehicle.

Intercity buses help to ensure equitable transportation access. The **Bureau of Transportation Statistics** compiles data on rural transportation access and found that in 2018, 79% of rural residents had access to intercity bus services, a nearly 10% increase from 2006. Targeted investments in stations and stops, which grew from 1,718 in 2006 to 2,632 in 2018, have helped to strengthen the network and grow ridership.

These services connect rural residents to major urban centers, offering connections to essential services and economic opportunities. State and local efforts to improve user experience and accessibility – such as comprehensive trip planners and connected statewide networks – can further bolster the appeal of intercity bus services and ensure they remain a sustainable mode of transportation for diverse populations.

Intercity buses cater to a diverse range of travel needs. Different use cases may include:

Urban to Urban Areas

Express routes linking major cities provide convenient and sustainable travel for commuters and leisure travelers in high-demand corridors.

Rural to Urban Areas

Intercity buses linking small towns in rural regions to larger urban hubs and activity centers provide vital transportation links for residents in areas with limited transit options. Operating at lower frequencies, typically offering a single roundtrip per day, these services ensure rural communities remain connected to essential services.

Rural Feeder Service

This specialized service utilizes small vehicles, offering demand-responsive rather than fixed-schedule transportation to connect rural areas with rail or air passenger services where feasible. By providing flexible and tailored transportation solutions, rural feeder services enhance connectivity and accessibility for residents in remote regions.

Special Events & Seasonal Services

Intercity buses can offer dedicated routes for special events and seasonal activities, catering to increased demand during specific times of the year.

For example, Bustang in Colorado provides special event routes:

- *Snowstang, offering weekend service from Denver to ski resorts during the winter.*
- *Bustang to Broncos for professional football games in Denver.*

Student Tourism

Intercity buses serve as a convenient mode of transportation for students traveling between educational institutions and urban centers.

For example, routes like the Ram's route, which provides weekend service between Colorado State University in Fort Collins and Denver, offer students affordable and accessible travel options.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

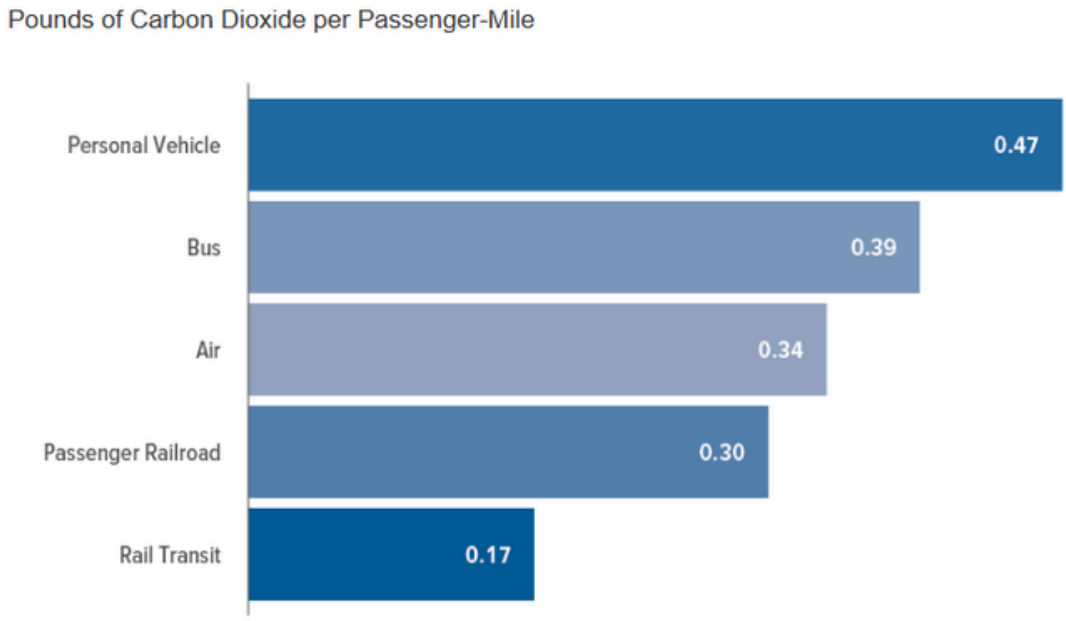
GHG EMISSIONS PER PASSENGER-MILE:

Several studies have assessed the carbon footprint of intercity bus travel, with a slight range in estimates across studies due to varying methodologies.

In 2019, carbon dioxide (CO_2) emissions from intercity buses (including charter buses and tour buses) **averaged 0.15 pounds per passenger-mile** (CBO, 2022).

- Rail transit averaged 0.17 pounds per passenger-mile.
- Personal vehicles averaged 0.47 pounds per passenger-mile.
- Transit buses, which often operate at a low capacity, averaged 0.95 pounds per passenger mile. Emissions per passenger-mile decline as the number of occupants increases.

The Union of Concerned Scientists, in a 2008 study, estimated intercity bus emissions to be **0.17 pounds per passenger-mile** (Union of Concerned Scientists, 2008). *Note, this includes upstream emissions.*



Carbon dioxide emissions per passenger-mile from travel by personal vehicles are higher on a per-mile basis than emissions from other forms of passenger travel (CBO, 2022).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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The Texas Transportation Institute estimated that motorcoaches emit 53 grams of CO_2 per passenger-mile (**0.12 lbs. per passenger mile**) compared to the second most efficient mode of travel, vanpool, which emits 106 grams of CO_2 per passenger-mile. For further reference, intercity rail emits 183.5 grams per passenger-mile and ferryboats emit 1,392 grams of CO_2 per passenger-mile (TTI, 2023).

CO_2 EMISSIONS FOR REAL-WORLD INTERCITY PASSENGER TRIPS

A trip by intercity bus can avoid significant greenhouse gas emissions compared to a trip of the same length taken by car, even in a hybrid car. A 2008 report found that generally, a couple boarding an intercity bus can cut their carbon nearly in half compared with driving even a hybrid car. If they take the bus instead of flying, they will cut their emissions by 55 to 75%, depending on the distance they travel (Union of Concerned Scientists, 2008).

A study comparing the operational CO_2 emissions across various travel modes for four different city pairs in the United States reveals traveling by bus or rail significantly reduces operational CO_2 emissions compared to car or air travel (Simon et al., 2022).

Operational CO_2 emissions (total) by scenario and main mode of travel – last-mile emissions included (Source: Simon et al., 2022).

City Pair	Car‡ (kg CO_2/per.)	Bus+ (kg CO_2/per.)	Air‡,+ (kg CO_2/per.)	Diesel Train (kg CO_2/per.)	Train (w/ car)‡ (kg CO_2/per.)	Electric Train (kg CO_2/per.)
Boston – New York	135.0	26.7	141.1	N/A	N/A	25.3
Los Angeles – San Diego	87.0	15.2	105.0	44.2	N/A	N/A
Washington – Orlando	548.0	121.9	273.5	210.6	369.2	N/A
Washington – Orlando (Family of 4)	137.0*	111.1*	246.6*+	185.5*	224.2*	N/A
St. Louis – Chicago	193.9	37.1	184.4	47.3	N/A	N/A

‡ Assumes last-mile mode was a car for all scenarios.
* Assumes car emissions are split among four people.
+ Air and bus service only includes passengers as air service does not allow for car transportation.

Application of Electric Vehicles:
The intercity bus industry is undergoing a shift towards sustainable solutions and practices, with a growing focus on electric vehicles. Major manufacturers like Motor Coach Industries (MCI) and Van Hool are introducing electric versions of their full-size intercity buses. For example, the MCI D-series coach is currently undergoing testing by USDOT at the Altoona Bus Test Center in Pennsylvania.

ELECTRIC BUS RANGE AND CHARGING

Current electric intercity buses have a range of 170 to 230 miles, with high-power plug-in charging taking around four hours to reach a full charge. Although they are not yet well suited for long-distance routes with continuous operation, electric buses have higher potential for shorter commutes with midday layovers and routes under 150 miles. Electric intercity buses could also service feeder routes from smaller cities or rural areas. To fully realize the benefits of electric intercity buses, a robust national charging network is essential (Schaper, 2022).

Emerging Niches in Intermodal Bus Travel:
Luxury bus services offer a potential alternative to air and car travel for business travelers, particularly for trips between 200-500 miles. These services can provide comparable or even faster door-to-door travel times compared to airplanes on certain routes, potentially at competitive prices. They may also offer a more relaxed and work-supportive environment compared to both air and passenger vehicle travel, due to amenities like Wi-Fi, work desks, and food service.
Their lower passenger density (20 to 30 passengers) compared to traditional intercity buses suggests potentially more limited greenhouse gas emissions avoided as compared to a higher carbon-intensity mode, particularly for medium-distance travel. However, more comprehensive analysis is needed to confirm environmental impacts of luxury services vs. traditional intercity buses and other modes of travel.

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Intercity bus services contribute to roadway safety by providing a reliable and comfortable transportation option, reducing the risks associated with long-distance driving, such as fatigue. Nearly 17% of fatal motor vehicle crashes in the U.S. involve a drowsy driver (Tefft, 2012).

There is limited data on motorcoach safety relative to long-distance car travel. However, studies of transit bus systems can provide some insight into the safety of intercity bus travel.

- In the U.S., for every 100 million person-trips, one study found that fatality rates for car occupants are 23 times higher than those for bus occupants (Beck, et al., 2007). Other research found fatality rates to be 66 times greater for car occupants than bus occupants per passenger-mile (Savage, 2013).
- A study of 10 bus routes in Montreal, Canada found that the rate of fatally or severely injured vehicle occupants is 6 times greater for car occupants than for bus occupants (Morency, et al. 2018).

The same study found that the rates of pedestrian and cyclist injuries are also significantly greater for car travel (4.1 times) than bus travel (Morency, et al. 2018).

COST SAVINGS

Intercity and inter-regional bus service are generally much less expensive than owning and operating a car. Research shows that shifting away from cars and towards more sustainable mobility options can save urban Americans an average of $2,000 each year (ITDP, 2024).

Virginia Breeze Bus Lines offers service between cities and towns in Virginia, Washington, D.C., and regional airports. Tickets range from $15 to $60, which can be more affordable than a private vehicle, particularly when considering parking costs (Virgina Breeze).

ECONOMIC GROWTH

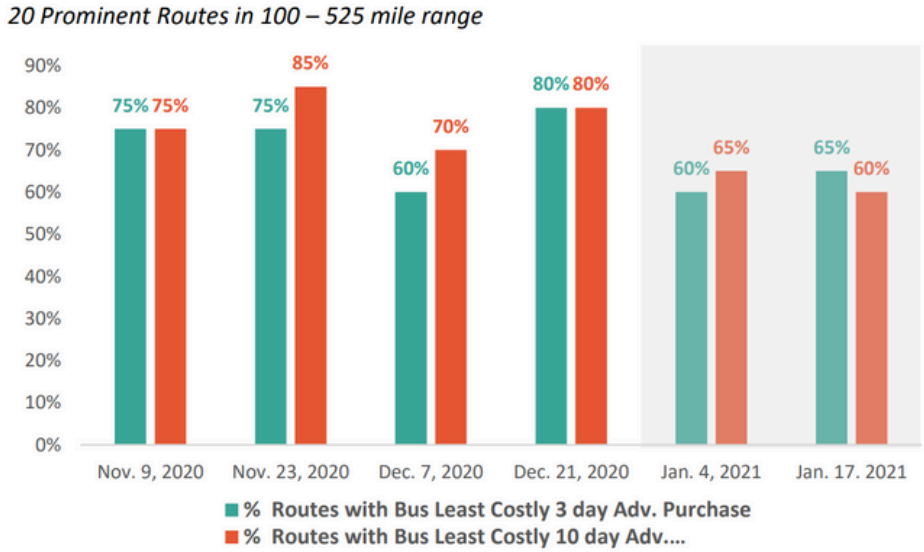
By connecting communities and promoting travel to diverse destinations, intercity buses stimulate economic activity. Motorcoach travel and tourism generates as many as 1.98 million jobs in communities across

the United States, paying over $86.4 billion in wages and benefits (American Bus Association, 2023).

"Student tourism" in the United States represents a significant portion of motorcoach tourism, encompassing 30.1% of passenger trips, highlighting the importance of intercity buses in facilitating student travel experiences (John Dunham & Associates, 2013).

ACCESSIBILITY AND EQUITY

Intercity buses represent a cost-effective alternative to driving or flying, offering affordable fares and reducing the financial burden of travel for individuals and families. A study using data from 20 bus routes in January 2021 found bus travel was cheaper than air and rail fares 60 to 85% of the time (Schwietrman et al., 2021).



The Percent of Routes in which Bus Fares are Lower than Air and Rail Fares (Source: Schwietrman et al., 2021.

Unlike traditional train or air travel, intercity buses can offer a network of pick-up and drop-off locations closer to where people live and work. This expands access to transportation for those with limited means or without access to personal vehicles. These benefits are fully realized when stops provide a comfortable and secure pre- and post-boarding experience (Talbott, 2011).

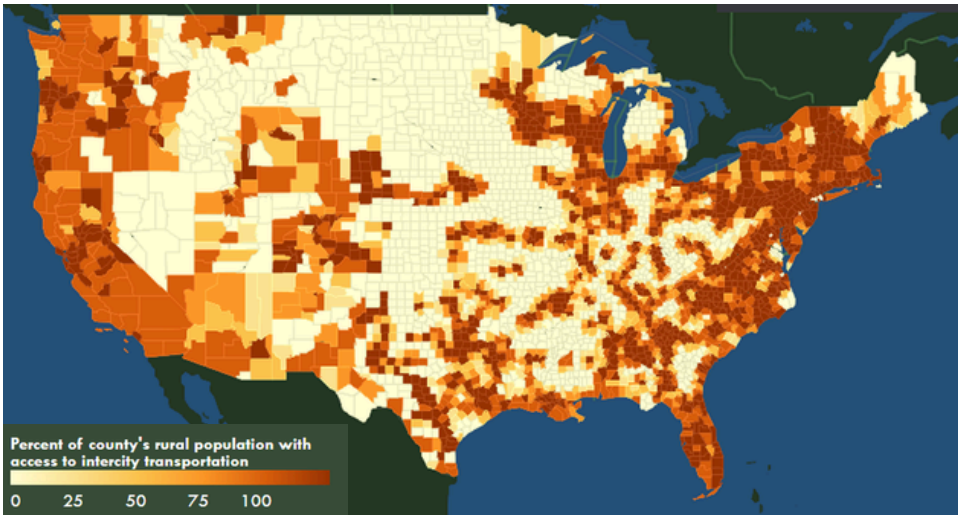
Implementing alternative ticket purchasing methods ensures inclusivity and accessibility for diverse populations, including elderly individuals and unbanked individuals (Pike et al., 2022).

Watch the National Rural Transit Assistance Program (National RTAP)'s video on how intercity bus transportation supports equitable and affordable access.

RURAL COMMUNITIES

Intercity bus services play a vital role in connecting rural communities to regional transportation hubs and activity centers, enhancing access to essential services, employment opportunities, and educational institutions.

As of 2021, 85% of the nation's 88.8 million rural residents had access to intercity transportation. Access is defined as living within 25 miles of an intercity bus stop (BTS, 2023).



Map displaying intercity bus access across U.S. counties (Source: U.S. DOT, Bureau of Transportation Statistics, Access to Intercity Transportation in Rural Areas).

AIR QUALITY AND HEALTH

Bus service helps to reducing the number of emissions-emitting vehicles on the road, which decreases air pollutants that are harmful to human health (Litman, 2024).

Since intercity buses are a denser form of transport, they allow for more efficient travel on a single gallon of fuel. Fuel savings translates directly into emissions savings and less air pollution. A typical intercity bus will get about 152 passenger-miles per gallon (MPG), compared to only 30 MPG for a single-occupancy vehicle (Schwieterman et al., 2022).

When considering a 2021 fleet average, motorcoaches have the lowest per-passenger emission rates for particulate matter among all on-road transportation modes, with 6.6 grams of PM2.5 per 1,000 passenger-miles compared to 1.9 for vanpool (2nd best), 6.8 for transit buses, and 7.5 for passenger cars (TTI, 2023).

COST CONSIDERATIONS

Intercity bus service typically requires less upfront capital investment compared with intercity rail, since buses can leverage the existing right-of-way. Capital expenses include vehicle purchase, ticketing counters and online platforms, and marketing. Operating expenses include fuel purchase and maintenance. Some services, such as the Virginia Breeze Bus Lines, have seen rising demand and revenues in recent years, which helps to offset operating costs (Schieterman, et al., 2024).

Government subsidies can help bridge gaps in intercity bus service and improve existing service, increasing ridership. For example, in 2022, Ontario Northland buses in Canada carried 281,790 passengers and 34,707 packages. Out of its $148 million annual budget, $95 million came from fares, while $54 million (36%) was provided by a provincial subsidy (Litman, 2024).

Intercity bus levels of service (LOS) scale with affordability and other factors, such as frequency, speed, and amenities. High LOS, where bus travel is much cheaper than driving, can attract travelers who would otherwise drive. Litman (2024) lists LOS A through F, where LOS A includes more than 25 daily trips, provides speeds as fast as driving, and includes amenities, such as free WiFi. LOS A can reach mode shares of 15 to 25%, while LOS D for comparison, with only 1 to 4 daily trips and costs comparable to driving, might only reach 3 to 6% mode share (Litman, 2024).

FUNDING OPPORTUNITIES

FTA's **Nonurbanized Area Formula Grant Program (Section 5311) Funding** requires 15% of each state's overall Section 5311 funding allocation be spent on rural intercity bus projects under Section 5311(f) unless the state certifies to the FTA that there are no unmet rural intercity needs, and that it has determined that there are no needs as the result of a consultation process that includes outreach to the intercity carriers and other stakeholders.

FHWA's **Surface Transportation Block Grant Program (STBG)** provides flexible funding that may be used by States and localities for projects to preserve and improve the conditions and performance on any Federal-aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects, including intercity bus terminals.

FTA's **Grants for Buses and Bus Facilities Program** supports state and local efforts to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low or no emission vehicles or facilities.

FTA's **State of Good Repair Grants Program** provides capital assistance for maintenance, replacement, and rehabilitation projects of high-intensity fixed guideway and motorbus systems to help transit agencies maintain assets in a state of good repair in urbanized areas.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** funds can be used to, install electrification infrastructure for buses, and support intermodal stations. CMAQ funds can also be used towards transit amenity improvements.

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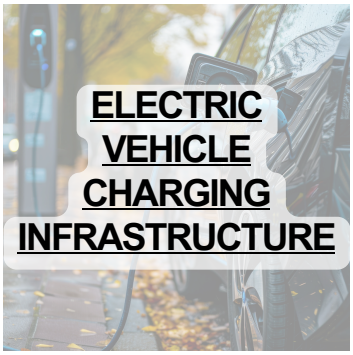
COMPLEMENTARY STRATEGIES

Cross-jurisdictional planning and collaboration can support efficient and high utilization intercity and cross-regional bus routes.



Electric vehicles and charging infrastructure are essential for the advancement of electric intercity buses.

Intercity rail and intercity buses together offer travelers flexible and efficient options for long-distance travel.

Expanded public transit options can support access to intercity bus lines and mutually reinforce use of both in-city and intercity transit networks.

In a rural context, transit oriented development would focus on a rural downtown or town center, which could co-locate with intercity bus routes, supporting additional economic growth and mobility options.

Including intercity bus routes and timing alongside intra-city public transit options supports public education about medium- and long-haul passenger public transportation options and encourages use of intercity buses.

Trip planning tools and modal integration support intercity bus operations by providing travelers with comprehensive information on routes, schedules, and ticketing options, enhancing the overall travel experience.

View All Strategies

CASE STUDIES

KAYAK PUBLIC TRANSIT

Kayak Public Transit in Pendleton, OR is administered by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The agency operates a rural regional transportation system reaching into southeastern Washington and northeastern Oregon, with three fixed routes and four long distance commuter bus services spread throughout four counties and connecting 15 communities. The name "Kayak" is reflective of the Cayuse/Nez Perce word "K'ay'ák" which means "to be free of obstructions." Some of those obstructions or obstacles were people not having a vehicle, not living in the town where they're employed, and not having access to education and medical services. Their transportation service currently provides nearly 100,000 rides per year. Kayak Public Transit was awarded the National RTAP 2019 Tribal System Award for their innovation, efficiency, commitment, and performance in the tribal transit industry.

BRECKENRIDGE FREE RIDE

(Source: Breck Free Ride)

The Free Ride system in Breckenridge, Colorado, a mountain destination that attracts year-round visitors, uses intercity buses to address traffic congestion and promote environmentally friendly travel options. The bus system is a convenient, and reliable option for users that otherwise would be traveling in private cars. The town Transit Agency, in a Livability Grant to the federal government, cited a reduction of 202,336 pounds of CO_2 emissions in a year from choice riders using the system (NASEM, 2012).

GREENWAY PUBLIC TRANSPORTATION

(Source: Greenway Public Transportation)

Greenway Public Transportation provides fixed-route, flex-route, and demand-responsive transportation in rural North Carolina through Western Piedmont Regional Transit Authority (WPRTA). Greenway saw the need to expand their service to rural areas, particularly to meet the needs of underserved riders. The service expansion initiative took about three years and involved many stakeholders, including county municipalities, government leaders, the Community Foundation of Burke County, representatives from the manufacturing and industry sectors, and non-profit organizations. The routes were tailored to include low-income and affordable housing as bus stops so underserved populations could access transit to get to town. There was a "ride-free" promotional period to help people learn and become acclimated to using public transit. This new route was advertised by the local public housing authority. After implementing the new flex routes, Greenway saw an increase in ridership of nearly 70%, from 1,300 riders in 2018 to 2,200 in 2019.

IMPLEMENTING INTERCITY BUS SERVICE: **WHAT TO READ NEXT**

Successful intercity bus networks rely on strong local, state, and private sector collaboration. Key considerations for state and local agencies may include:

Safe and Comfortable Bus Stops
Agencies can invest in bus stops with adequate shelter and amenities. In some cases, establishing a transit hub may be necessary to serve as a centralized location for intercity bus services, facilitating seamless transfers between routes and connecting with other modes of transportation. Coordinating with existing infrastructure such as transit centers or transportation hubs can optimize the use of resources and improve connectivity within the transportation network.

> Read InterCity Transit's guidance on Intercity Bus Stops.

First/Last-Mile(s)
Addressing the journey to and from intercity bus facilities is crucial to ensure accessibility for all riders. Implementing feeder services or carpool programs can facilitate connections for passengers traveling from remote areas or areas without direct access to bus stops. Providing convenient and reliable transportation options to and from bus facilities enhances the overall travel experience and encourages modal choice towards intercity bus services.

Bus charging infrastructure on key corridors can support an industry shift towards electric vehicles.

> See FHWA's EV Toolkits for Rural Electric Mobility and Urban Electric Mobility infrastructure.

Parking Guidelines and Permitting
Coordination between city DOTs and private operators to establish clear parking policies, can minimize unnecessary idling and ensure smooth layovers between trips.

> See the University of Delaware UTC's reference document Curbside Intercity Bus Industry: Research of Transportation Policy Opportunities and Challenges.

KEY CONSIDERATIONS FOR BUS OPERATORS:

Tracking Systems and Signage

Implementing bus tracking systems or on-site support allows passengers to monitor bus arrival times and receive real-time updates on potential delays, ensuring passenger safety and comfort, particularly in adverse weather conditions or during nighttime travel. Utilizing signage and outreach campaigns can effectively communicate the benefits of bus travel and inform passengers about routes, schedules, and fare options.

> Pace buses in Chicago, Illinois facilitate data collection and communication between drivers and passengers using Intelligent Bus System (IBS) technology. Read more here.

Accessible Booking and Ticketing

Establishing a seamless booking process will help attract new ridership. User-friendly features such as those below contribute to overall convenience and accessibility:

- Having to purchase tickets online can be challenging, especially for elderly and non-English speaking riders. To address this, intercity bus operators can implement alternative ticket purchasing methods such as phone reservations or in-person ticket sales at terminals. Additionally, providing multilingual customer support and offering clear instructions in multiple languages on the booking platform can enhance accessibility for non-English speakers.
- Implementing accessible options for individuals who may not have access to traditional banking methods is crucial for ensuring inclusivity and equity in intercity bus services. Some operators, such as Greyhound offer cash payments at convenience stores and participating retail spaces, allowing users to make reservations online and then complete their payment in person.
- Offering new schedule options that require transfers necessitates that bus lines deal with late-arriving buses, cancellations, customer confusion, and other issues at transfer points. Metasearch travel websites, including Busbud and Wanderu are pivotal to making travelers aware of the new schedule options, allowing them to comparison shop, and providing customer support.

RESOURCES

GENERAL RESOURCES

Depaul University Chaddick Institute for Metropolitan Development Intercity Bus Research Hub: This research on intercity bus service spans nearly a decade, with year-in-reviews for the past five years highlighting the innovation and technological advances undertaken by the intercity bus industry in the United States.

TOOLKITS AND MODELING APPROACHES

U.S. DOT Bureau of Transportation Statistics Intercity Bus Atlas (ICBA): The ICBA is a mapping application which features scheduled intercity bus service data. The BTS collects the data from various provider websites, compiles them into a single, geospatially enabled database, and then publishes them for research, analysis, and planning.

American Bus Association Local Economic Impact Study: This interactive map details information on the local economic contributions of motorcoach-based group tourism in counties and select cities across the United States. When an area is selected, a report can be generated to share with stakeholders.

Transportation Research Board Toolkit for Estimating Demand for Rural Intercity Bus Services: This toolkit provides a sketch-planning guide and supporting CD-ROM–based tools that can be used to forecast demand for rural intercity bus services.

FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Calculator Toolkit: This toolkit is designed to estimate the air quality and greenhouse gas reduction benefits of different projects, including transit buses.

RURAL SPECIFIC

FTA National Rural Transit Assistance Program (RTAP): This is a program of the FTA administered by the Neponset Valley TMA, serves to create rural and tribal transit solutions through technical assistance, collaboration, training, and transit industry materials. They host trainings, resources, and peer networking for public agencies and rural operators.

FTA and Transportation Research Board Effective Approaches to Meeting Rural Intercity Bus Transportation Needs, TCRP Report 79: This report addresses funding for intercity bus projects; discusses barriers to implementation; and identifies strategies for initiating, preserving, and enhancing effective intercity bus transportation.

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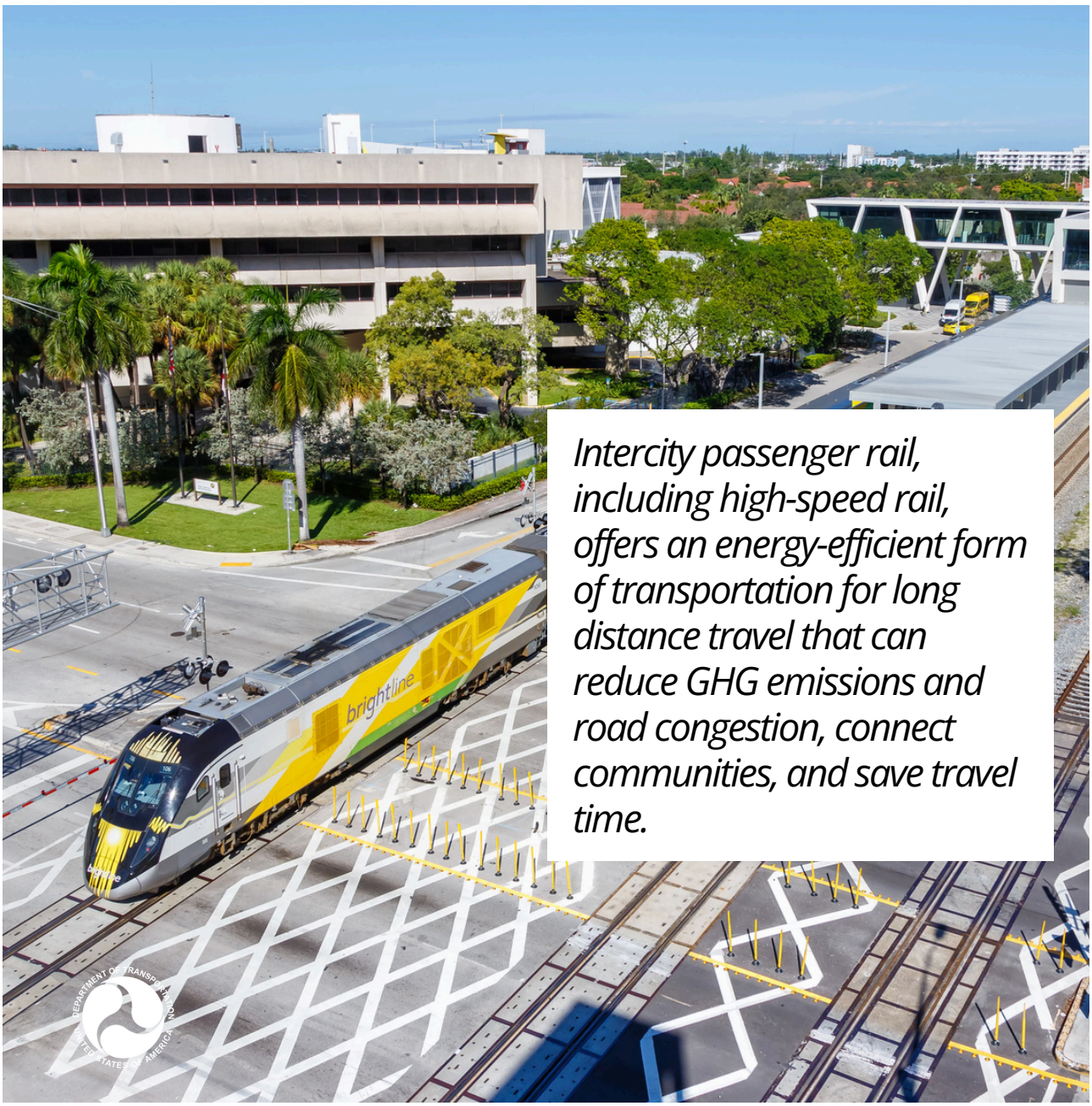
For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

INTERCITY PASSENGER RAIL



Intercity passenger rail, including high-speed rail, offers an energy-efficient form of transportation for long distance travel that can reduce GHG emissions and road congestion, connect communities, and save travel time.

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Best Suited for:
Long Term
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Intercity rail service connects cities over longer distances than commuter or regional trains. Intercity rail travel, including high-speed rail (HSR), **is generally less carbon-intensive than air or single-occupancy car travel** on a passenger-mile basis. Emissions savings are even greater on the electrified portion of rail which currently includes Amtrak's Northeast Corridor, the busiest passenger railroad corridor in the U.S. network. Giving passengers the choice to take passenger rail can help avoid greenhouse gas emissions from long distance travel and vehicle congestion. Additionally, **intercity passenger rail has the potential to save travel time in comparison to driving or flying** when accounting for time spent at and travelling to the airport.

(Source: Amtrak)

(Source: Brightline)

Did you know?

Amtrak's Connect US Vision calls for 20 million more passengers and more than 30 new routes by 2035.

Outside the U.S., rail emissions per passenger-mile are, on average, 80% lower than those of air travel due to high rates of electrification and railcar occupancy, suggesting that **additional investments in U.S. passenger rail could provide even more benefits from a climate perspective, relative to other modes.** High-speed rail, which operates at speeds above 155 mph on newly built lines and above 124 mph on upgraded lines, may provide the greatest climate benefits in terms of offering mode choice, particularly along congested routes. The Federal Railroad Administration (FRA), Amtrak, state and local governments, and private companies are working together to enable high speed rail in the U.S., in support of more convenient, efficient passenger travel.

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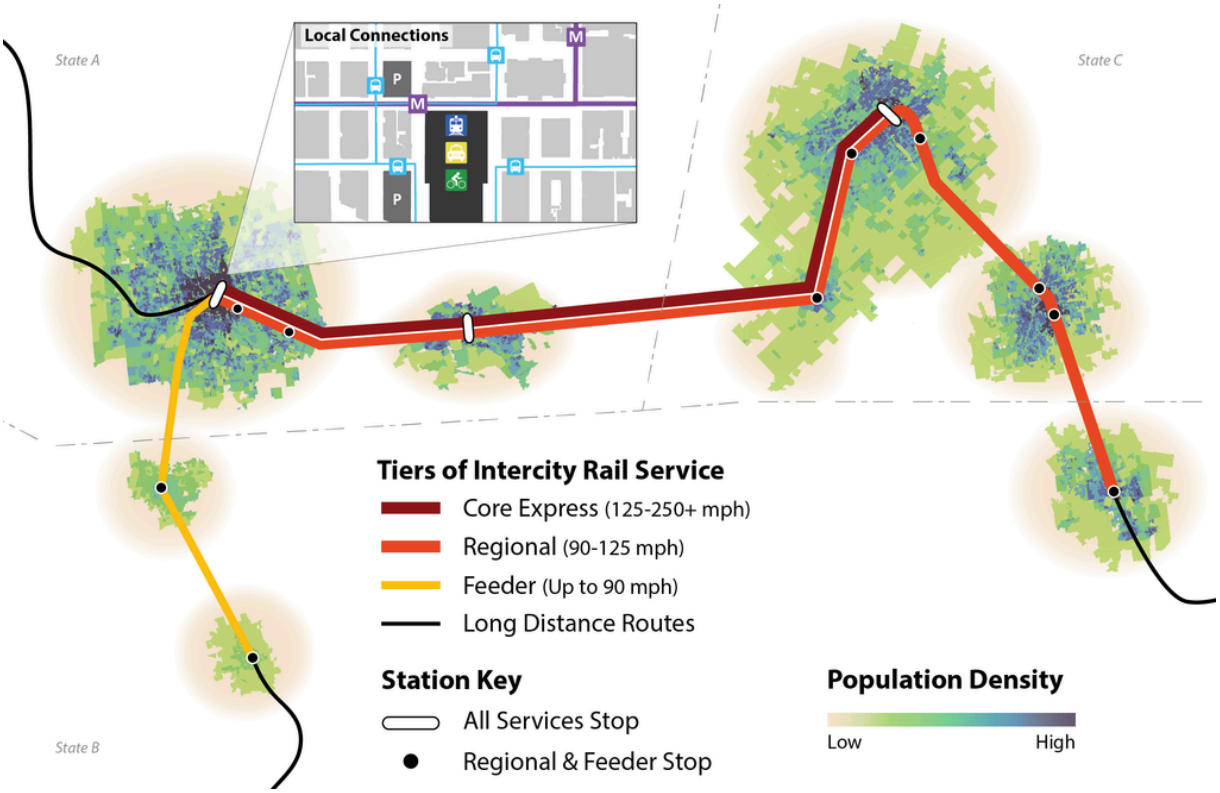
Intercity rail supports communities of different sizes from cities to rural areas. The figure below highlights how different tiers of rail service connect the wider regional area. *(Source: FRA)*



GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

RAIL TRAVEL IS MORE EFFICIENT THAN SINGLE-OCCUPANCY PASSENGER VEHICLES AND AIR TRAVEL

Travel on intercity rail in the U.S. is approximately 30% less energy intensive per passenger than travel in single-occupancy vehicles (Davis and Boundy, 2022).

Traveling from St. Louis, MO to Chicago, IL by diesel train emits four times fewer CO_2 emissions (per passenger mile) than traveling by a gasoline-powered car (Simon et al., 2022).

The Heartland Flyer, an intercity rail line connecting Oklahoma City, OK and Fort Worth, TX produces only one quarter of the GHG emissions per passenger mile compared with the same trip taken by single occupancy vehicle and only one third of the GHG emissions from air travel (NASEM, 2015).

The Northeast Corridor is the busiest passenger railway in the U.S., accounting for 32.2% of customer trips but only 2.1% of track-miles in Amtrak's network (Amtrak, 2022). Because the route is electrified, emissions reductions are even greater as compared to other modes of travel. For example, traveling from Boston to New York on the Northeast Corridor has more than five times fewer GHG emissions than traveling by air (Simon et al., 2022). This is even when accounting for the GHG emissions from electricity production in the region. Greenhouse gas emissions avoided with electrified intercity passenger rail using clean energy would be significantly higher.

INTERCITY PASSENGER RAIL CAN REDUCE VEHICLE MILES TRAVELED (VMT)

Surveys of rail passengers indicate that 60-70% of rail travelers would use a personal vehicle for travel if the rail service was unavailable. This finding suggests that passenger rail provides an important alternative to personal vehicle use (Sperry & Collins 2018).

Highlighting the potential to reduce VMT, a survey of intercity travelers along the Northeast Corridor found that 38% of drivers and 54% of bus riders would take the train if their first choice travel mode were unavailable (Northeast Corridor Commission, 2015).

INCREASED USE OF PASSENGER RAIL HAS THE POTENTIAL TO GREATLY REDUCE TRANSPORTATION SECTOR EMISSIONS

One study modeled what U.S. transportation sector emissions would have been in 2019 if electric-powered high-speed rail was widely available. The results indicated that emissions would have been 23% lower, largely due to the study predicting that more travelers would have widely chosen high-speed rail over short-haul flights (<2000 km) (Zheng, 2022).

(Source: Amtrak)

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Like air travel, traveling by rail is one of the safest modes of transportation. In the U.S., for the same distance traveled, a person is 17 times more likely to die while driving a car than if they were taking the train instead (Savage, 2013).

Intercity rail service contributes to roadway safety by providing a reliable and comfortable transportation option, reducing the risks associated with long-distance driving, such as fatigue. Nearly 17% of fatal motor vehicle crashes in the U.S. involve a drowsy driver (Tefft, 2012).

ACCESSIBILITY AND EQUITY

Amtrak offers discounts for students, children, seniors, people with disabilities, military personnel, and veterans (Amtrak, n.d.).

Intercity rail increases access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities.

COST SAVINGS

Traveling on passenger rail can save customers money on tickets compared to air travel.

Average cost savings traveling by rail rather than air on different U.S. routes (Glusac, 2019).

Trip	Average Cost Savings
Boston – New York City	$110
Seattle – Vancouver	$203
Los Angeles – San Diego	$70
Tampa – Fort Lauderdale	$82

Discounting tickets at off-peak travel times can incentivize ridership: A study in Switzerland demonstrated that a discount of one percentage point would cause a 0.16% increase in rescheduled trips among riders who would have traveled by train regardless of the discount. The impact of this slight discount demonstrates the potential of discounts at off-peak travel times to encourage rail ridership (Huber et al., 2022).

ECONOMIC GROWTH

Investment in intercity rail generates large economic return: Amtrak's services across the country return between $7 and $8 billion per year to the national GDP which is four times the typical annual investment (Rail Passengers Association, 2022).

Investment in intercity rail creates new jobs: The Brightline West high speed rail project is projected to create 35,000 construction jobs and 1,000 permanent jobs once service begins (The White House, 2023).

AIR QUALITY AND HEALTH

Reducing the number of vehicles on the road (especially in densely-populated areas) will decrease the concentration of air pollutants that are harmful to human health (VTPI, 2023).

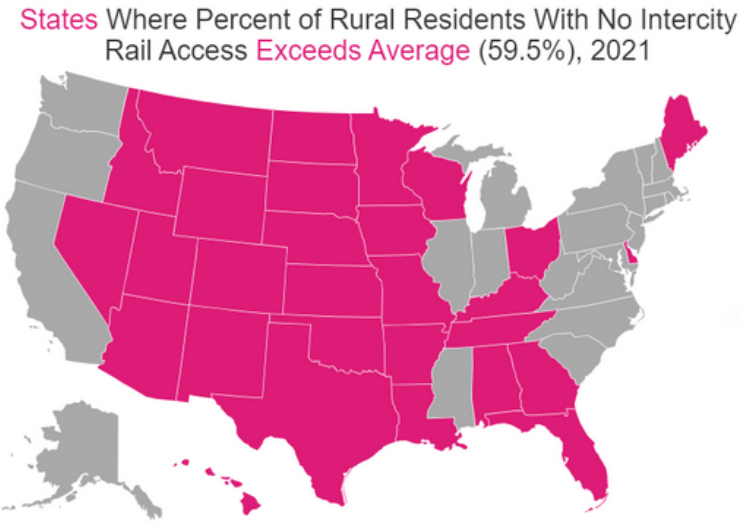
Passenger rail travel in Virginia removes around 271 million miles of VMT from Virginia roads (Department of Rail & Public Transportation, 2017), which in turn avoids the emissions from those vehicles.

Brightline West, connecting Los Angeles and Las Vegas with a fully electric high speed rail line, is projected to result in 3 million fewer cars traveling on Interstate 15 every year, as passengers opt to use high speed rail (Lazo, 2023).

RURAL COMMUNITIES

Intercity rail connects residents to opportunities and resources across communities. For example, workers gain access to jobs and businesses gain new customers from other communities.

Intercity rail provides mode choice for intercity trips and can connect residents to other transportation modes. For example, 54% of rural residents did not live within 75 miles of a major airport (Bureau of Transportation Statistics, 2023). Rail provides the opportunity to choose an alternative mode instead of enduring long drives for intercity trips.



Map showing transit access for rural residents (Source: Bureau of Transportation Statistics, 2023). Access to Intercity Transportation database is available here.

COST CONSIDERATIONS

The cost to implement intercity passenger rail varies widely depending on the scale, scope, and location of the project.

The cost of constructing intercity passenger rail, including high speed, can be less than constructing and maintaining roadways.

In 2019, the Washington State Department of Transportation examined different strategies to ease congestion on Interstate-5 which connects Portland, Oregon, Seattle, Washington, and Vancouver, Canada. Estimates for constructing a HSR line are around $24-42 billion while estimates for adding a lane to the highway are $108 billion (Scruggs, 2019).

Investing in intercity passenger rail can reduce cost burdens on other transportation modes by relieving congestion and reducing costs related to maintenance and traffic incidents.

Investment in the Northeast Corridor rail system has the potential to save the aviation and highway systems $8.2 billion per year by 2040 (Northeast Corridor Commission, 2014).

FUNDING OPPORTUNITIES

FRA's **Corridor Identification and Development Program** is a comprehensive intercity passenger rail planning and development program that will help guide intercity passenger rail development throughout the country and create a pipeline of projects ready for implementation. Grantees receive funding to develop a scope, schedule, and cost estimate for a service development plan.

FRA's **Federal-State Partnership for Intercity Passenger Rail Grant Program** provides funding for capital projects that reduce the state of good repair backlog, improve performance, or expand or establish new intercity passenger rail service. Funded projects will expand passenger rail service and improve existing corridors, making it more competitive with higher-emission intercity travel modes.

FRA's **Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program** funds projects that improve the safety, efficiency, and reliability of intercity freight and passenger rail. CRISI funds can be used for a wide variety of projects supporting the development of rail, ranging from capital investments to workforce development and training, to research and development, and more.

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COMPLEMENTARY STRATEGIES

Connecting bus rapid transit routers to intercity rail can expand access to both and mutually reinforce opportunities for riders, especially for rural communities.

Commuter benefits incentivize employees to take public transit to the office which may include intercity passenger rail for longer commutes.

Cross-jurisdictional planning and collaboration can support efficient and high utilization intercity and cross-regional rail facilities.

Expanded public transit options can support access to intercity bus lines and mutually reinforce use of both in-city and intercity transit networks.

Shared micromobility and microtransit systems, located at intercity rail stations can help address last-mile travel and further support access to intercity passenger rail services.

Including intercity passenger rail locations and service schedule alongside intra-city public transit options supports public education about medium- and long-haul passenger public transportation options and encourages use of intercity passenger rail.

In a rural context, transit oriented development would focus on a rural downtown or town center, which could co-locate with intercity rail station routes, supporting additional economic growth and mobility options.

View All Strategies

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CASE STUDIES

LOS ANGELES TO LAS VEGAS HIGH-SPEED RAIL - CALIFORNIA/NEVADA

The Nevada Department of Transportation (NDOT) received $3 billion from U.S. Department of Transportation (DOT) to help construct a Los Angeles to Las Vegas high-speed rail line in partnership with Brightline West, an intercity passenger high-speed rail service company. The new service will feature all-electric trains that travel at over 186 miles per hour, covering the 218-mile corridor in two hours and ten minutes, twice as fast as the average drive time. The project will break ground in 2024 and is expected to open before the Los Angeles Summer Olympic Games in 2028.

Brightline West High Speed Rail Project Map (Source: Nevada Department of Transportation).

BRIGHTLINE HIGH SPEED RAIL - FLORIDA

(Source: Brightline)

Brightline is the 235-mile long high-speed railway connecting Miami, West Palm Beach, Fort Lauderdale, Aventura, Boca Raton, and Orlando, with plans of expanding to Tampa. Trains travel up to 125 mph, so passengers can travel between downtown Miami and downtown Fort Lauderdale in 30 minutes between Miami and Orlando in 3 hours. A December 2023 report shows that ridership increased 29% from the prior year. The expansion to Orlando during this period led to an increase of long-distance ridership which accounted for 49% of riders.

RIGHT-OF-WAY ACQUISITION AND INFRASTRUCTURE IMPROVEMENTS - VIRGINIA

In Virginia, the acquisition of right-of-way from track owner, CSXT, has been a priority strategy to expand rail service options throughout the state. In addition, capital improvements such as a new passenger-dedicated bridge crossing the Potomac River and an increase in Amtrak service will reduce bottlenecks. The extension of the Roanoke Amtrak line to Christiansburg, Virginia, a town with less than 24,000 residents, will improve service to rural travelers. A 60% increase in service on the Virginia Railway Express, the region's commuter rail service, is expected from these changes which are 1/3 the cost of expanding I-95 in Virginia.

(Source: Virginia Passenger Rail Authority)

IMPLEMENTING INTERCITY PASSENGER RAIL: **WHAT TO READ NEXT**

The high cost of train tickets combined with the lack of high-speed options remains a barrier to widespread intercity rail acceptance in the U.S. Strategies that focus on lowering cost and increasing speed can help encourage mode choice.

A boom in European rail travel has been attributed to increased competition in the rail industry lowering prices such that they are often lower than flights as well as consumer demand for sustainable transportation modes (Mcclanahan, 2024).

> To learn more about costs and rail management, read PPIAF's Railway Reform: Toolkit for Improving Rail Sector Performance.

Public-private partnerships are useful for improving rail service and increasing the passenger base.

Intermodal partnerships can make it easier for passengers to choose modes. For example, partnerships between airline and rail companies are becoming more common. United Airlines and Lufthansa Airlines partnered with the Deutsch Bahn to allow passengers flying through Frankfurt Airport to book rail tickets at the same time as their airline ticket (Cole, 2023).

Many intercity passenger rail operators must negotiate with freight operators to gain access to or acquire rail lines. Successful agreements reduce delays and increase passenger rail service.

> To learn more about rail partnerships, read Transportation Research Board's Guidebook for Implementing Passenger Rail Service on Shared Passenger and Freight Corridors.

RESOURCES

GENERAL RESOURCES

FRA Rail Climate Considerations: This webpage provides an overview of strategies to address climate concerns. Links are included for resources, research, initiatives, and funding opportunities.

FRA Resources: This webpage provides links to guidance regarding planning, management, operations, grants, regulations, and NEPA.

FRA Maps- Geographic Information System: This webpage includes links to different maps relevant to rail safety and equity.

International Union of Railways Rail Adapt - Adapting the railway for the future: This report comes from the United Kingdom. The analysis of adaptation strategies and global case studies can be useful for U.S. stakeholders.

Transportation Research Board Guidebook for Implementing Passenger Rail Service on Shared Passenger and Freight Corridors: The guidebook outlines the steps to a successful public-private partnership from negotiations to modeling.

Texas A&M Transportation Institute Public Use of Rail Right-of-Way in Urban Areas Final Report: the report focuses on negotiating agreements with private freight companies, detailing different strategies with case study examples.

FRA Railroad Capital Project Guidance: This guidance document outlines the timeline, steps, and project management strategies to implement a railroad capital project.

TOOLKITS AND MODELLING APPROACHES

PPIAF Railway Reform: Toolkit For Improving Rail Sector Performance: This toolkit details strategies for improving the performance of the rail sector and provides numerous global case studies.

(Source: Brightline)

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

MICROMOBILITY DELIVERIES, MICROHUBS, AND LAST-MILE SOLUTIONS

Micromobility deliveries offer low-carbon, cost-effective last-mile solutions, reducing congestion and enhancing urban livability.

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Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Emissions from the last mile of delivery can account for up to 50% of total delivery carbon emissions and delivery trucks and vans contribute to congestion and safety issues. Micromobility deliveries offer a sustainable solution for the last-mile delivery challenge. They utilize compact vehicles like cargo bikes, drones, and delivery robots to efficiently transport goods over short distances, filling the gap between distribution centers and final destinations. **Micromobility devices can replace or supplement delivery trucks and vans in a range of cases**, from urban cores and downtown areas to rural communities.

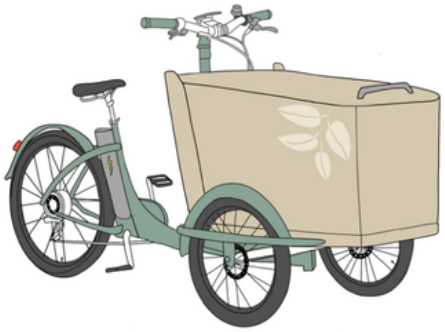
Micromobility deliveries can help to reduce noise and emissions from delivery trucks, mitigate congestion, and free up curb space. They can also expand access to delivery services in rural communities.

Use cases for micromobility deliveries span various sectors, including retail, food delivery, and healthcare. Micromobility deliveries can play a crucial role in urban resiliency planning, offering solutions for emergency response and disaster relief efforts. In light of recent disruptions like the COVID-19 pandemic, micromobility deliveries have demonstrated their resilience by providing essential services such as grocery and medicine delivery, ensuring continuity in supply chains and meeting the needs of vulnerable populations.

Did you know?

Research suggests that roughly 80% of a delivery driver's time is spent parked, with most deliveries completed on foot (Dalla Chiara et al., 2021). Cargo bikes can address this inefficiency by eliminating wasted time searching for parking and streamlining short-distance deliveries.

The effectiveness of micromobility delivery solutions is context-based, influenced by factors such as city density, urban form, existing infrastructure, and the nature of the delivery task. Tailoring micromobility solutions to specific environments and delivery requirements ensures optimal performance and integration within the broader transportation network, ultimately contributing to more sustainable and resilient cities.



Source: University of Washington, Urban Freight Lab

Elements of Micromobility Deliveries and supportive infrastructure may include:

Devices and Vehicles

- **(E-)Bikes and (E-)Cargo Bikes:** These versatile vehicles come in various configurations, offering significant payload capacities.
- **Electrified Dollies and Carts**: These emerging tools support on-foot deliveries, reaching doorsteps, stores, and lockers.

Worker Hubs, Success Story

Through a $1 million federal grant, NYC is transforming existing underutilized infrastructure, like vacant newsstands, to create critical street 'deliveristas hubs' that provide workers with charging stations, shelter, rest areas, and bike repair servicing. Read more, here.

Supporting Infrastructure/Programs

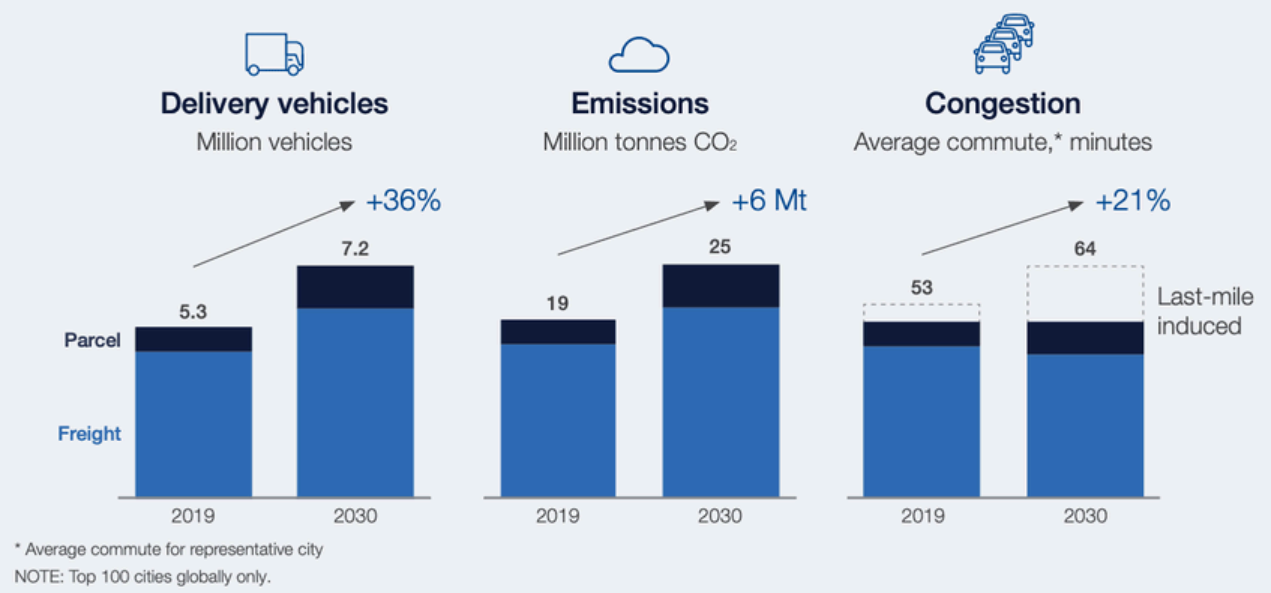
- **Microhubs:** These act as transfer points, facilitating the movement of goods from larger vehicles to smaller ones suitable for micromobility deliveries. They may also offer parcel lockers and serve as a midway point between Urban Consolidation Centers (UCCs) and final pick-up locations.
- **Wide Bike Lanes:** Dedicated lanes create a safe and efficient environment for micromobility deliveries.
- **Curb Management and Dedicated Parking:** Designated areas for loading and unloading optimize delivery workflows.
- **Delivery Lockers:** These lockers provide a secure location for package handoff, addressing the "Final Fifty Feet" challenge by completing the last stage of delivery.
- **Charging Infrastructure:** Convenient charging stations ensure smooth delivery operations for electric micromobility devices.
- **Secure Micromobility Storage**: Secure parking facilities address parking needs and deters theft.
- **Worker Hubs**: Dedicated spaces provide delivery personnel with important amenities, fostering a safer, more efficient work environment.
- **Rider Education:** Investing in workforce education empowers delivery personnel with the knowledge and skills to navigate urban environments safely and efficiently.

GHG REDUCTION POTENTIAL

This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

MICROMOBILITY DELIVERIES IN CONTEXT OF URBAN FREIGHT

Current State of Urban Deliveries: In an "unguided adoption" scenario, where no interventions are made, the number of urban deliveries in the world's top 100 cities is projected to increase by 36% from 2019 to 2030. This surge is expected to result in 6 million tonnes of additional CO_2 (World Economic Forum, 2020).



Cities are facing increases in delivery vehicle activity, emissions, and congestion associated with deliveries. Between 2019 and 2030, the number of delivery vehicles on roads globally is expected to grow by 36% assuming no intervention taken. (Source: World Economic Forum, 2020)

Emissions from Urban Delivery Vehicles: Urban freight plays a significant role in transportation emissions. For instance:

- In Madrid, urban freight accounts to 10% of journeys but accounts for 20% of carbon emissions from transportation sources (Madrid 360, 2021).
- Last-mile delivery is responsible for approximately 30% of CO_2 emissions in the logistics sector (Kardinal, 2024).
- A model from NYU Tandon's C2SMARTER University Transportation Center indicates that residential parcel deliveries in NYC contributed to 0.05% of total daily vehicle-kilometers traveled (VKT), equating to 14.4 metric tons of carbon equivalent emissions per day (Yang et al., 2023).

CARGO BIKES AS A VIABLE SOLUTION

A report published in 2018 by cargo e-bike consulting group Transport for Quality of Life concluded that **10-30% of trips by delivery and service companies might be substitutable by (e-)cargo bikes** (Transport for Quality of Life, Ltd, 2019).

> ***Current Urban Delivery Vehicle Composition:*** *Freight trucks currently make up about two-thirds of urban delivery vehicles, with the remainder consisting of light commercial vehicles and passenger cars (World Economic Forum, 2020).*

The New York City Department of Transportation (NYCDOT) **estimates that two cargo bicycles can replace one delivery truck**, resulting in approximately 14 tons of CO_2 savings annually—equivalent to 30,872 passenger car miles (NYCDOT, 2023).

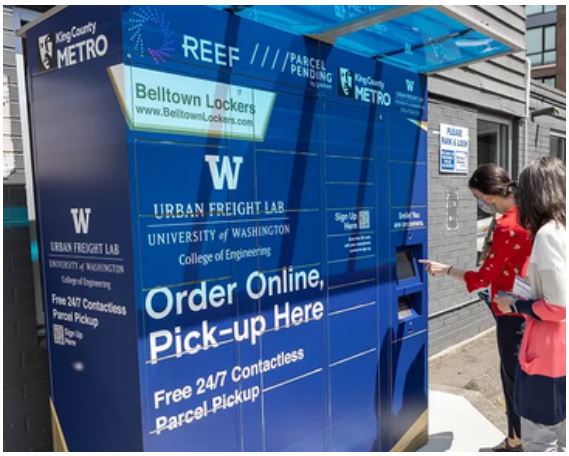
> I*mpact of Cargo Bikes in NYC*: In 2022, NYC cargo bikes completed over 130,000 trips, delivering more than 5 million packages and reducing CO_2 emissions by over 650,000 metric tons (NYCDOT, 2023).

Existing bike lane infrastructure in NYC can support a substitution of 17% of parcel deliveries by cargo bikes, leading to an 11% reduction in vehicle-kilometers traveled (VKT). Additionally, adding 3 km of bike lanes to connect Amazon facilities could increase this substitution benefit from 5% to 30% VKT reduction. A further expansion of 28 km of bike lanes could double the citywide substitution potential to 34%, saving an additional 2.3 metric tons of carbon equivalent per day (Yang et al., 2023).

Transport for London, which manages a metropolis similar in size to NYC, anticipates cargo bikes could replace up to 17% of van kilometers traveled in Central London by 2030 (Transport for London, 2023).

A pilot program in Seattle found that carrier lockers can reduce delivery truck curbside dwell time by as much as 33% and cut delivery times by as much as 78% (Ranjbari et al., 2023).

> The final 50 feet extends beyond the last mile of a trip and is often the most resource-intensive stage of the delivery process. Innovative solutions, such as delivery lockers, are being explored to enhance efficiency.



Source: University of Washington, Urban Freight Lab

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CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Micromobility deliveries contribute to safer streets by reducing the presence of large delivery vehicles in shared spaces, minimizing the risk of collisions with pedestrians, cyclists, elderly, and other vulnerable road users who are more susceptible to injury in accidents involving larger vehicles (AIANY, 2022).

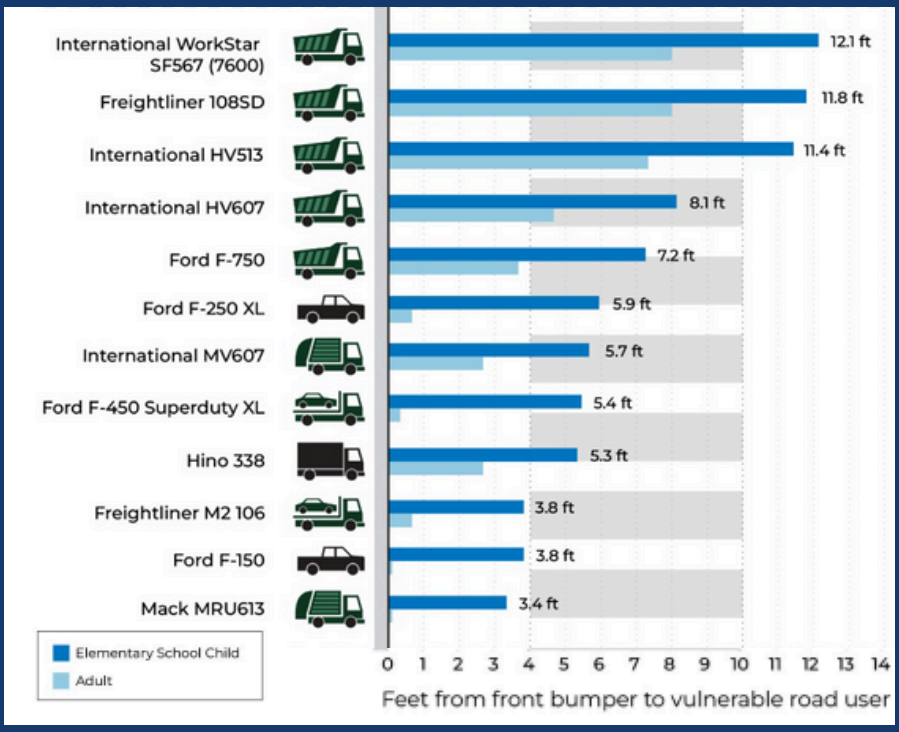
Delivery vehicles often block lanes of street traffic, contributing to a larger pattern of traffic chaos and creating dangerous conditions for vulnerable road users. Distinct from congestion, traffic chaos refers to traffic patterns that create confusion and force drivers and other road users to make quick decisions (AIANY, 2022).

Delivery vehicles often block lanes of street traffic, contributing to a larger pattern of traffic chaos. Distinct from congestion, traffic chaos refers to traffic patterns that create confusion and force drivers and other road users to make quick decisions (AIANY, 2022).

Large vehicles have poor sight lines.

A study by the Boston Blind Zone Safety Initiative details the first distance point at which a vehicle can see an adult and elementary school child in a crosswalk (Brodeur et al. 2023).

Nearest point at which an adult and child are visible to a driver in a standard crosswalk. The number listed in feet corresponds to the distance from the vehicle bumper to a child in the crosswalk. (Source: Brodeur et al. 2023)

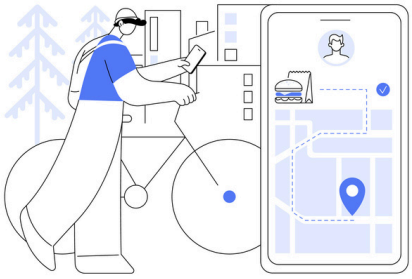


ACCESSIBILITY AND EQUITY

Cargo e-bikes have a significantly lower environmental footprint compared to traditional delivery vehicles. Studies show they generate just 12% of the total *social and environmental cost* of a diesel van and 14% of an electric van (Just Economics, 2022).

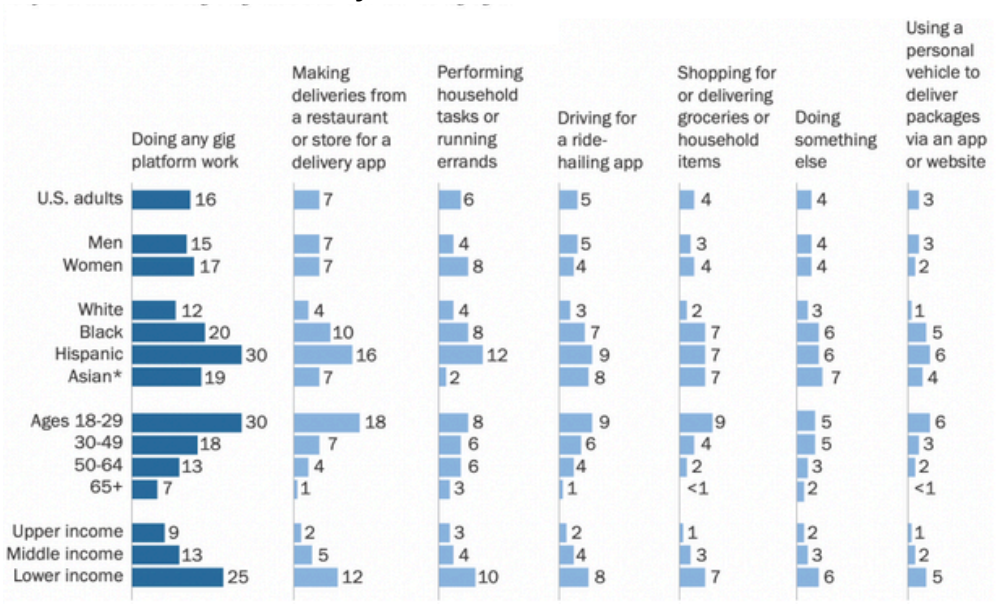
Social and environmental costs are the negative externalities that are not reflected in the prices of goods and services. In the context of delivery, social and environmental costs include things like air pollution, noise pollution, and climate change.

Micromobility's lower barrier to entry, i.e., not requiring a car or commercial driver's license, could create more equitable access to job opportunities. Micromobility deliveries can also offer flexible work schedules that cater to individuals with childcare responsibilities, those seeking part-time work, or students.



A Pew Research Center survey found that 16% of US adults reported earning money through an app-based platform in 2021, the majority of whom were people of color (Anderson et al., 2021).

The increasing number of women in delivery roles (44% in 2021 compared to 36% in 2019 according to Garin et al., 2023) suggests a trend towards a more inclusive workforce in the delivery sector.



*Asian adults were interviewed in English only.
Note: Gig platform work refers to earning money by using a mobile app or website to find jobs that directly connect workers with people who want to hire them, or by using a personal vehicle to deliver packages to others. White, Black and Asian adults include those who report being only one race and are not Hispanic. Hispanics are of any race. Family income tiers are based on adjusted 2020 earnings. Those who did not give an answer are not shown.
Source: Survey of U.S. adults conducted Aug. 23-29, 2021.
"The State of Gig Work in 2021"

Percent of U.S. adults who have earned money by different gig jobs. (Source: Pew Research Center)

16% of Americans have earned money via an online gig platform; adults under 30, Hispanic adults, and those with lower incomes especially likely to do this jobs.

AIR QUALITY AND HEALTH

By shifting deliveries to smaller, more maneuverable vehicles like bicycles and electric scooters, micromobility deliveries reduce the number of emissions-emitting vehicles on the road (especially in densely populated areas).

Using bicycles and electric scooters for deliveries has the potential to reduce urban noise pollution (Farooqui et al., 2020).

Micromobility deliveries provide flexible access to fresh food options, particularly for people with limited mobility, car dependence, residence in a food desert, or underlying health concerns who have limited access to fresh food or may benefit from minimized exposure in crowded grocery stores. This convenience and reduced risk were especially valuable during the COVID-19 pandemic, ensuring continued access to essential goods.

ECONOMIC GROWTH

Micromobility deliveries can foster a more human-scaled street experience, potentially increasing foot traffic and local business activity. To incentivize the adoption of cargo e-bike deliveries, State and local governments have successfully established green loading zones and zero emissions delivery zones and added bike lanes or bike parking in downtown areas. *See the City of Portland, which is piloting a Zero-Emission Delivery Zone.*

Micromobility deliveries can support the growing demand of e-commerce by completing last-mile deliveries to end users. In 2020, e-commerce accounted for 20% of all sales in the United States (U.S. Census, 2021).

The shift to online shopping requires new ways to address increasing delivery demands and associated increases in delivery-related GHG emissions, especially with sellers offering next-day delivery options and free shipping (SANDAG, 2021).

Boston Delivers, an e-cargo bike delivery pilot program focuses on carrying out final mile deliveries for businesses and organizations dedicated to expanding access to healthy and affordable food in two Boston neighborhoods, Allston & Brighton (City of Boston 2023).

Denver Food Rescue uses e-cargo bikes to save surplus fresh food from local markets and grocery stores and deliver it to No Cost Grocery Programs, reducing food waste and providing nutritious options to underserved communities.

COST SAVINGS

Micromobility allows for quicker and more agile navigation through traffic-dense areas, potentially reducing delivery times and costs.

A cost modelling and simulation of last-mile characteristics demonstrates that the cost for last mile cargo bike delivery in densely populated areas in European cities is €1.60 (2015 U.S. $1.78) per unit, while the standard delivery within a city, with motorized vehicles is €2.91 (2015 U.S. $3.23). These results indicate a possible cost reduction of up to 45% in urban areas if cargo bikes are used for deliveries (Wrighton & Reiter, 2015).

Micromobility deliveries have the potential to alleviate congestion and the associated time costs by reducing the number of delivery vehicles during peak hours.

In an "unguided adoption" scenario, meaning no intervention, growth in urban deliveries could increase average commute time by 21% (purely last mile delivery induced), equaling an additional 11 minutes of commute time for each passenger every day by 2030 (World Economic Forum, 2020).

A study in NYC found a single double-parked delivery truck on average affects 43 cars, and totals over $240 million lost a year in time and pollution (Goldstein et al., n.d.)

RURAL COMMUNITIES

Micromobility deliveries can fill gaps in health care service by offering fast and efficient transportation of essential medical supplies, prescriptions, and even diagnostic samples.

Upstate Medical University's Outpatient Pharmacy introduced a drone-delivered prescription pilot service for direct home patient delivery in November 2023 (Upstate Medical University, 2023).

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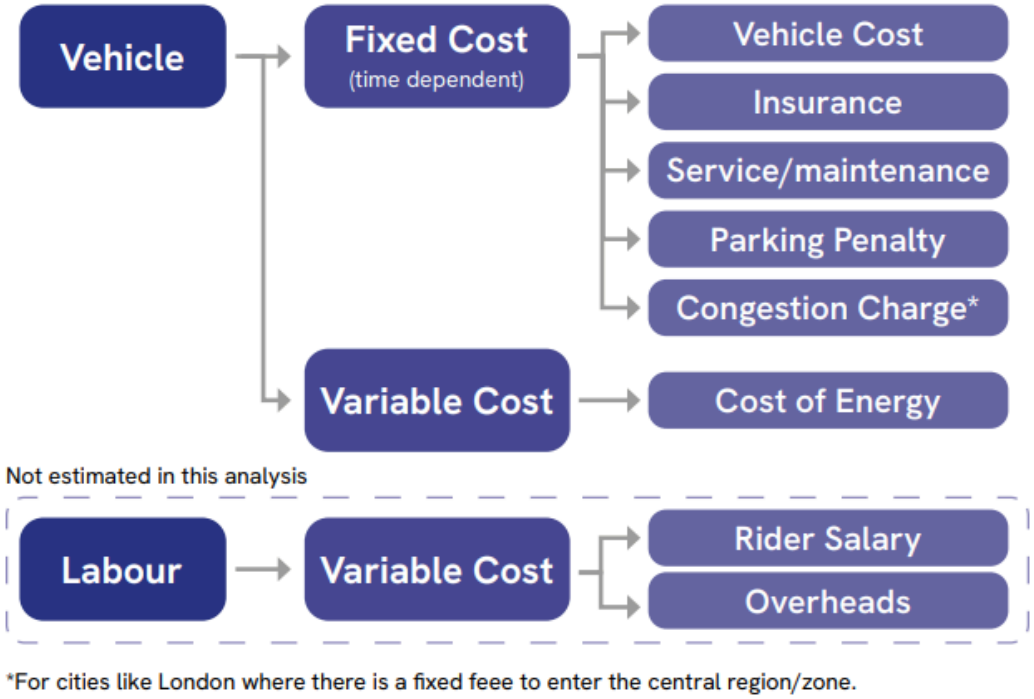
COST CONSIDERATIONS

COST OF IMPLEMENTATION

A report evaluating cargo bike delivery performance in Brussels found electric cargo bikes are over ten times cheaper to operate than a van in urban areas (Kale, 2023).

Adding fixed and variable costs, total yearly expenses are €2,066 per e-cargo bike, €10,782 for the Ford Transit van, and €10,296 for the Citroen e-van. Despite the same 20,200 parcels delivered, e-cargo bikes cost 1/5 the amount per parcel (€0.10) as the vans (€1.05-€1.10).

Considering a 2 km beeline service radius, drones costs €1.44 per shipment and the sidewalk robots delivery costs €1.13 per shipment (Li & Kunze, 2023).



Cost estimation structure for full delivery cost. (Source: Kale, 2023)

COST EFFECTIVENESS

Micromobility deliveries offer significant cost-saving advantages for logistics companies, particularly when considering the last-mile challenge.

For logistics companies, the last mile is the most complex part of the journey, representing over half the overall cost (Dolan, 2022). Micromobility's agility in congested urban areas can significantly reduce delivery times and associated labor costs.

> *Studies show busy city streets can consume 9-15 minutes just finding parking for traditional delivery vehicles (Sheth et al., 2019). Micromobility eliminates this wasted time and associated parking fees. Although this research does not focus solely on delivery trucks, it serves as a revealing proxy for parking challenges that trucks experience.*

E-cargo bikes are more cost effective than delivery trucks for deliveries in close proximity to the distribution center (less than 2 miles for the observed delivery route with 50 parcels per stop and less than 6 miles for the hypothetical delivery route with 10 parcels per stop) and at which there is a high density of residential units and low delivery volumes per stop (Sheth et al., 2019).

FUNDING OPPORTUNITIES

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Delivery/logistics is included as a technology area for eligible projects.

The Joint Office of Energy and Transportation's **Communities Taking Charge Accelerator** Program funds projects that will expand community e-mobility access and provide clean reliable energy. Funding opportunities for FY24 include Expanding E-Mobility Solutions through Electrified Micro, Light and Medium-Duty Fleets.

COMPLEMENTARY STRATEGIES

Micromobility delivery services rely on the infrastructure established within active transportation networks. Leveraging bicycles and scooters for last-mile deliveries, these services contribute to the efficient movement of goods while complementing efforts to reduce traffic congestion and emissions in urban areas.

Freight digitalization strategies, such as GPS tracking and eco-routing, streamline dispatch and route optimization, enabling micromobility deliveries to efficiently navigate congested urban areas.

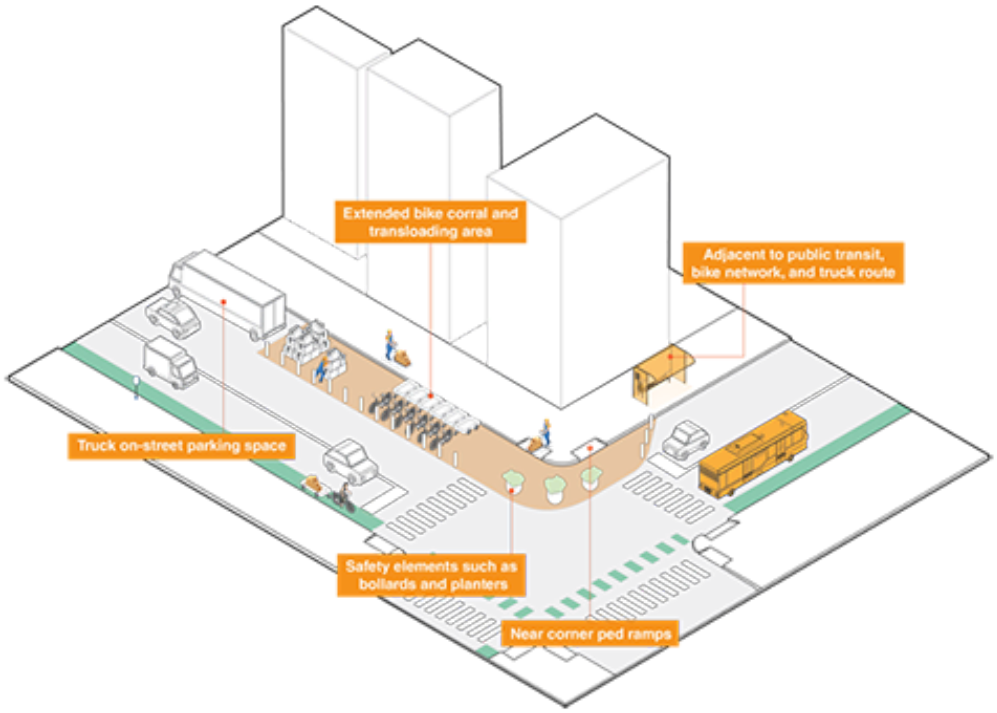
Integrating micromobility deliveries with off-peak delivery can enhance the overall effectiveness of freight movement and help reduce GHG emissions. Off-peak delivery times can alleviate congestion and improve efficiency for micromobility deliveries. Conversely, micromobility delivery can provide flexible and efficient last-mile solutions during off-peak times.

There are synergies between intermodal freight and micromobility deliveries in last-mile delivery optimization, where micromobility can complement intermodal freight by facilitating efficient distribution within urban areas, reducing GHG emissions.

View All Strategies

CASE STUDIES

NYC LOCAL DELIVERY HUB PILOT



Source: NYC DOT

New York City DOT is set to launch a new microhub pilot program in Summer 2024, aiming to transform the city's delivery landscape. The pilot introduces microhubs, local delivery points which will facilitate the shift from large trucks to more sustainable transportation options for the final delivery stretch. In response to the growing e-commerce demand, these microhubs are expected to reduce traffic congestion, enhance air quality, and improve public safety. With up to 20 hub sites in the pilot, NYC DOT plans to monitor operations and collect data, paving the way for a permanent local delivery hub program. The move aligns with the city's broader strategy to rethink curb space and prioritize sustainability in urban logistics.

SEATTLE ZERO-EMISSIONS DELIVERY ZONE

The Seattle Neighborhood Delivery Hub is part of the Zero Emissions Last Mile Delivery Pilot in Seattle developed through collaboration between the University of Washington Urban Freight Lab, the Seattle DOT, and private companies. The Delivery Hub is one of the country's first zero-emissions last-mile delivery pilots and is expected to help consolidate freight vehicle trips and reduce congestion and emissions associated with last-mile delivery. The program consists of microhubs or central drop-off/pick-up locations and integrates eco-friendly vehicles and transport modes like cargo bikes or walking. Delivery Hubs will also utilize common carrier parcel locker systems allowing carriers to transport multiple packages during a single stop and reducing idle time. The hubs are an important part of Seattle's Transportation Electrification Blueprint, including the goal of transitioning 30% of goods delivery to zero emissions by 2030.

Benefits of a Microhub
Source: University of Washington, Urban Freight Lab

SAN FRANCISCO, CA: E-BIKE DELIVERY PILOT

With funding from DOE's Vehicle Technologies Office, the San Francisco Environment Department carried out a pilot program in collaboration with app-based food delivery companies to shift deliveries from vehicles to e-bikes. The pilot will gather data to better understand impacts on delivery efficiency, safety, worker income, congestion, and emissions.

IMPLEMENTING MICROMOBILITY DELIVERIES, MICROHUBS, AND LAST-MILE SOLUTIONS : **WHAT TO READ NEXT**

Collaboration, thoughtful policy, and a focus on safety and equity are crucial for successful implementation of micromobility deliveries. Key considerations include:

Building a Collaborative Ecosystem: Micromobility delivery programs necessitate a well-coordinated effort.
Stakeholders may include:

- City Officials: Responsible for establishing regulations, infrastructure development, and safety protocols.
- Fleet Managers: Manage the micromobility delivery vehicles, ensuring proper maintenance and efficient operations.
- Departments of Transportation & Public Works: Oversee infrastructure planning and modifications to accommodate micromobility deliveries.
- Departments of Consumer & Worker Protection: Implement regulations to ensure fair treatment of delivery workers and consumer safety.

The Environmental Defense Fund developed a guide on freight stakeholder engagement. The report provides guidance on developing an engagement strategy, along with insight into some of the best practices used to develop productive stakeholder partnerships for improving freight movement. The report can be accessed here.

New York City's recent establishment of the Department of Sustainable Delivery offers a real-world example. This department aims to regulate the booming e-bike delivery sector, prioritizing safety, worker well-being, and environmental benefits. Read more, here.

- **Rethinking Payment Structures for Worker Safety and Equity:** Current payment structures in app-based delivery services often incentivize speed over safety. This can lead to reckless driving, putting both delivery workers and pedestrians at risk. Additionally, low wages can create challenges for worker well-being.

- **Optimizing Curb Management:** A diverse array of curb needs necessitates policies to guide which uses get prioritized. While cargo bikes require less space than traditional delivery vehicles, efficient curb management is crucial. Designated pick-up and drop-off zones ensure safer deliveries and minimize disruption to traffic flow.

The Institute of Transportation Engineers developed a Curbside Management Practitioners Guide that provides guidance on best practices curb space allocation. Available here.

The Urban Freight Lab is a public-private partnership housed at the University of Washington. The Lab explores urban freight research topics in a collaborative setting with the goals of reducing GHG emissions from urban freight transportation and increasing urban freight efficiency. Current focus areas include sustainable last-mile solutions and curb management using autonomous delivery vehicles, cargo bikes, and drones. Learn more about their research here.

RESOURCES

GENERAL RESOURCES

University of Washington, Urban Freight Lab: This resource focuses on improving urban freight systems through innovation and collaboration, with a particular interest in sustainable solutions like cargo e-bikes.

MIT Urban Mobility Lab: This resource investigates various aspects of urban mobility, including the role of new technologies and logistics models in optimizing last-mile deliveries.

Biking the Goods: How North American Cities Can Prepare for and Promote Large-Scale Adoption of Cargo e-Bikes. Urban Freight Lab, University of Washington: This white paper explores the potential of cargo e-bikes for last-mile deliveries in North American cities, outlining challenges, opportunities, and strategies for large-scale adoption.

The Future of the Last-Mile Ecosystem, World Economic Forum, 2020: This report from the World Economic Forum examines trends and innovations shaping the final leg of delivery journeys, including the rise of sustainable options like cargo bikes.

TOOLKITS AND MODELLING APPROACHES

RMI's E-Bike Impact Calculator Tool for Local Governments: The e-bike calculator estimates the impact of e-bikes as a substitute for short vehicle trips, based on a city-wide e-bikes goal; it also estimates the impact of an e-bike incentive program. Impacts are provided in terms of GHG emissions and VMT reductions, as well as cost savings.

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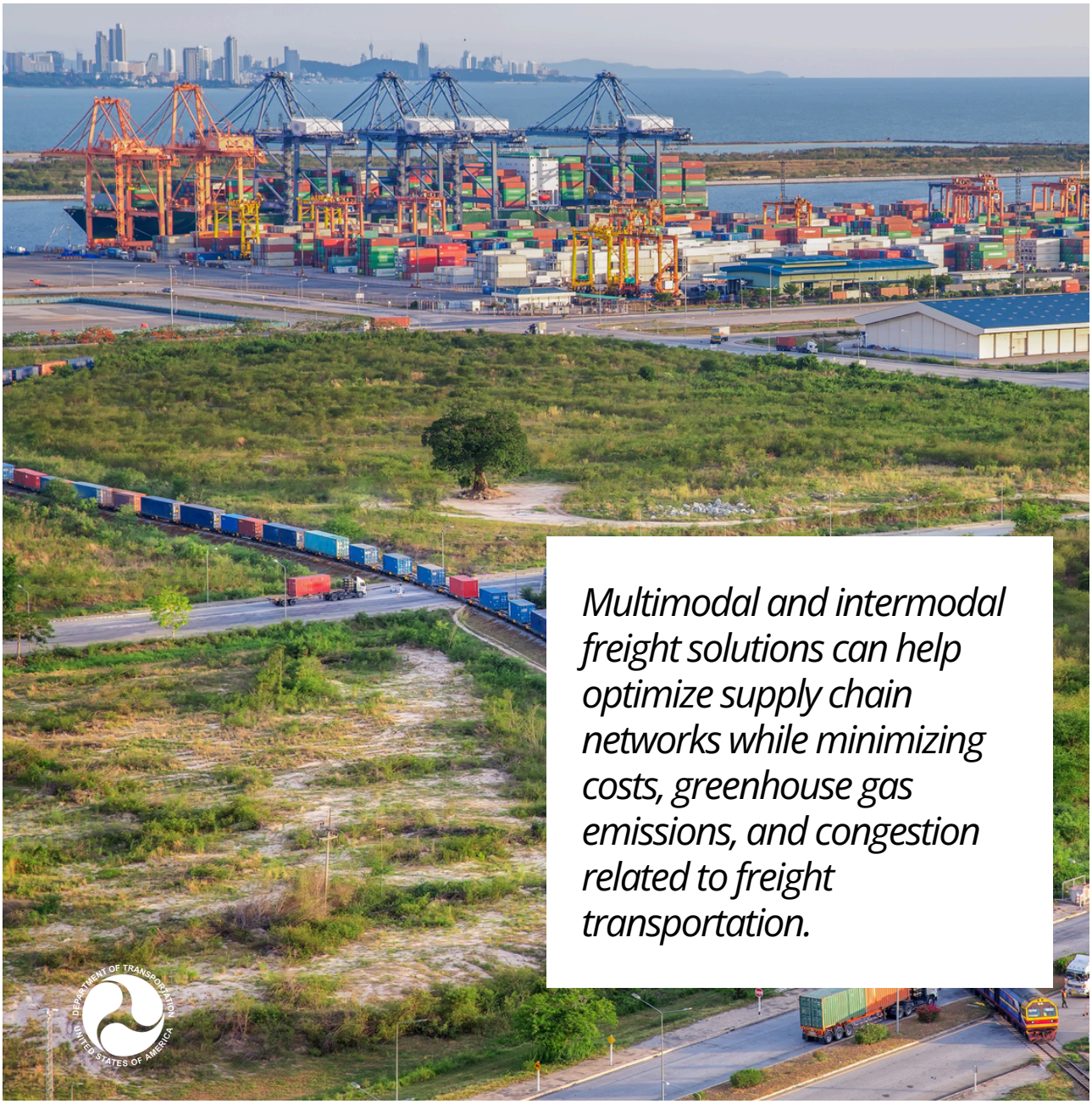
For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

MULTIMODAL AND INTERMODAL FREIGHT PLANNING



Multimodal and intermodal freight solutions can help optimize supply chain networks while minimizing costs, greenhouse gas emissions, and congestion related to freight transportation.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Intermodal vs. Multimodal

Both intermodal and multimodal transport entail transporting goods by more than one mode of transportation; however, intermodal transport involves multiple contracts with different carriers while multimodal transport involves only a single contract. Additionally, containers used in intermodal freight often adhere to international dimension guidelines, such that freight can remain in the same container when transferred between modes (e.g., from a container ship to a railcar).

For transporting similar goods over repetitive distances, rail and maritime shipping are generally more energy efficient and less carbon-intensive than truck shipping, which currently accounts for most of the freight transported in the U.S. Freight modes are not interchangeable for every single trip. For example, rail cannot serve the purpose that trucks and electric cargo bikes do in last-mile deliveries, nor could it replace maritime for overseas trade. However, investing in freight, rail, and maritime infrastructure can increase the options available to shippers for lower-carbon, more efficient transport of freight.

Investments may promote shifting certain shipments from trucks to maritime or rail. Argonne National Laboratory found that an estimated 4.1% of truck freight activity could be shifted to rail, resulting in 4.4% reduction in total freight CO_2 emissions by 2040. Rail optionality can also make it easier to take advantage of multiple modes for the same shipment. For example, freight could be transferred by rail for the largest distance of a shipment then transferred by truck to the final destination. Improved energy efficiency, through both fuel economy upgrades and higher utilization of lower-emission freight modes leads to both cost savings and enhanced supply chain resilience in addition to reduced greenhouse gas (GHG) emissions.

Increasing utilization and development of inland ports could boost non-highway shipments, both as an alternative to some truck and rail routes and as a component of multimodal shipments. Facilitating multimodal transfers through facility upgrades and innovative technology can also promote lower-emission shipments. Intermodal hubs or terminals are strategically located facilities where two or more transport modes converge to

transfer goods and passengers more efficiently. With optimization and other improvements, these hubs can reduce GHG and criteria pollutant emissions, as well as regional vehicle miles traveled (VMT).

Freight consolidation is another key strategy which can be used to improve the efficiency of goods movement. For example, shippers can merge less-than-truckload (LTL) and low-density shipments into full-truckload intermodal container shipments headed to and from ports and optimize container weight and volume to reduce the number of containers needed. Companies can also use less packaging to fit more products into each container, thus reducing overall number of containers, and truck or rail delivery miles in and around ports.

Last-mile Transport

Emerging modes such as electric cargo-bikes, electrified drones, and autonomous robots may also play an important role in decarbonizing last-mile deliveries. These technologies are covered in more detail in the Freight Digitalization and Micromobility Deliveries pages.

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Examples of intermodal facilities include:

Intermodal Connectors

Infrastructure and operational improvements to roads that provide the "last-mile" connection between major rail, port, airport, and intermodal freight facilities.

Port-to-Rail Facilities

Intermodal hubs situated near ports provide links between maritime and rail transport (e.g., on-dock rail).

Rail Intermodal Corridors

Similar to inland ports, rail intermodal involves long-haul movement of shipping containers and truck trailers by rail combined with a truck or marine transport at one or both ends.

Inland or Dry Ports

Ports that allow containers to be moved by rail from seaports to intermodal yards located in less densely populated areas, away from the more congested port itself, for further processing and distribution.

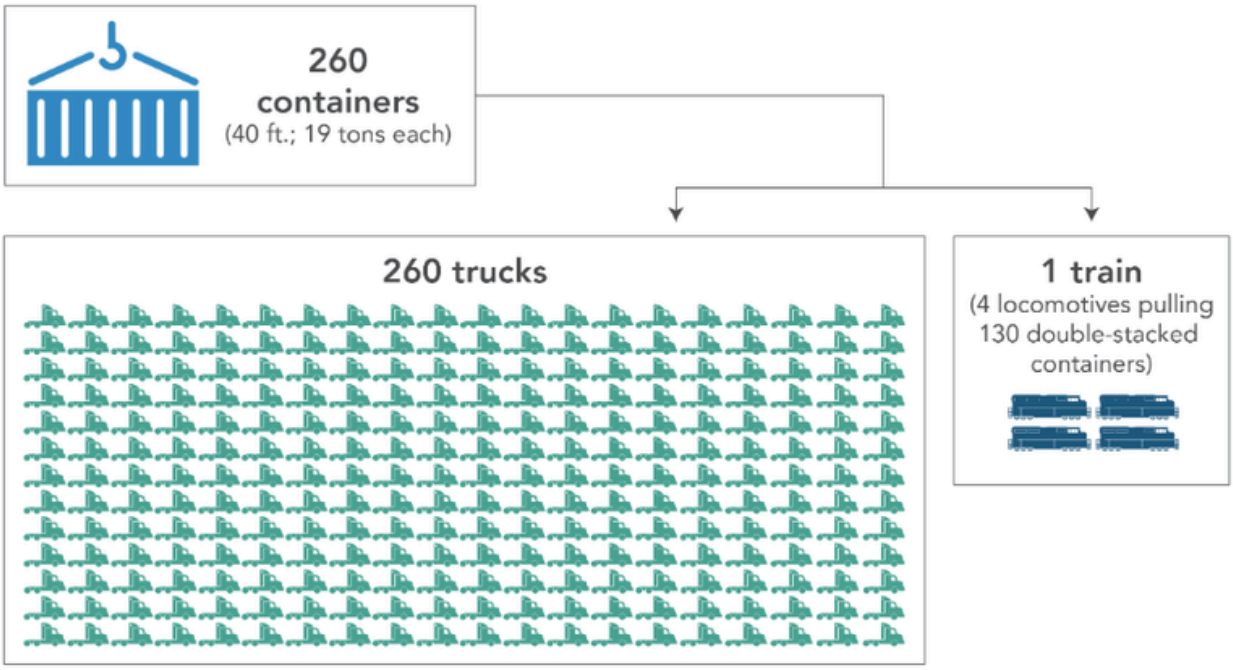
Spotlight on *Inland Port Dillon - Port of Charleston*: Port Dillon provides importers and exporters with a direct connection to the Port of Charleston via CSX rail. The port is located within a prime 3,400-acre industrial site and in close proximity to Interstate-95. It handles imports and exports for companies such as Harbor Freight Tools and also serves the regional agricultural community.

GHG REDUCTION POTENTIAL

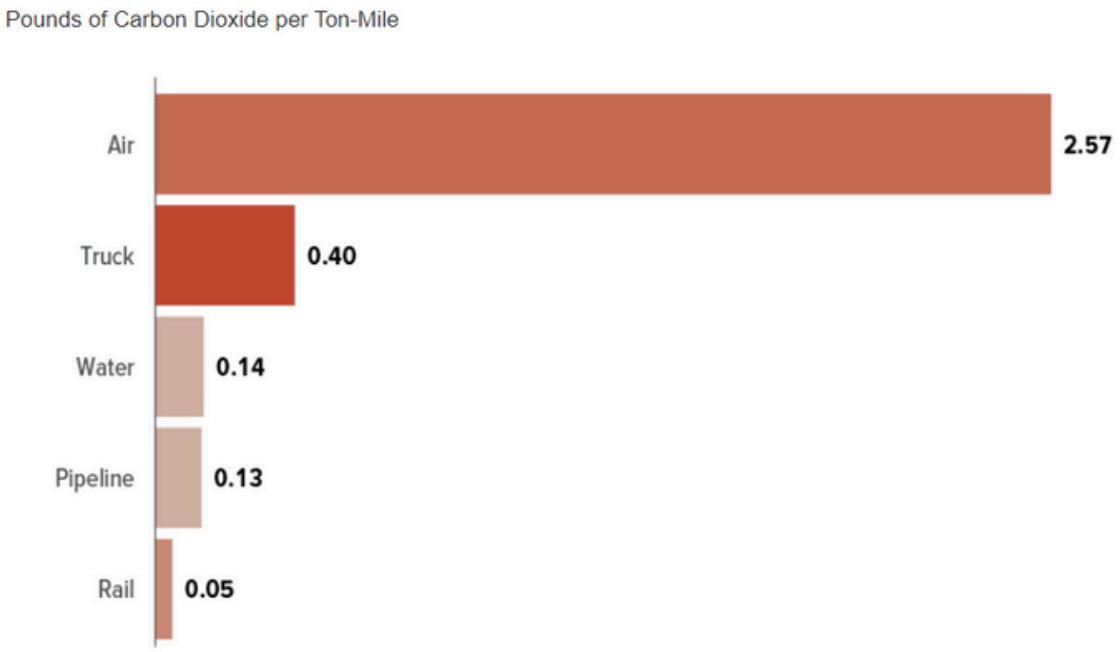
This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

MODAL SHIFT OPPORTUNITIES

Rail and barge shipping create significant opportunities for carbon reduction in the supply chain. On a per-ton-mile basis, rail and inland barge transport emit 0.05 lbs. and 0.14 lbs. of CO_2 per ton-mile, respectively, compared with 0.40 lbs. of CO_2 per ton-mile from trucking. Therefore, depending upon route distance and the additional truck drayage required, rail and barge modes can offer substantial CO_2 efficiency improvements relative to over-the-road freight (CBO, 2022).



Each truck can transport one cargo container, while a typical train can transport 260 containers. While exact greenhouse gas and criteria pollutant emissions per mile vary depending on distance traveled and engine type, rail transport typically has substantially lower emissions in most use cases (CARB, 2020).



Average Carbon Dioxide Emissions per Ton-Mile of Freight, by Mode of Transportation, 2019 (CBO, 2022).

A study by Argonne National Laboratory evaluated the potential for increased freight rail utilization in the U.S. based on commodity flows and rail level of service information. An estimated 4.1% of truck freight activity could be shifted to rail, resulting in 4.4% reduction in total freight CO_2 emissions by 2040. These values only consider commodities that have the potential to be shifted from truck to rail based on tonnage, transport distance, and time sensitivity of the commodities, and specifically exclude time-sensitive and/or delicate commodities (meat/seafood, electronics, and precision instruments) (Zhou et al., 2017).

In the New York metropolitan region, where the trucking industry delivers nearly 90% of the city's goods on 120,000-plus trucks daily, initiatives outlined in the Freight NYC plan are projected to reduce truck modal share by approximately 5%. This modal share reduction would eliminate up to 40 million truck miles, 71,500 metric tons of GHG emissions, and 30,000 pounds of particulate matter annually. Strategies outlined in the plan include developing a “hub and spoke” marine-based freight system, constructing a rail transfer center, and developing freight hub connections (New York City Department of Transportation, 2021).

Completion of the Norfolk Southern Crescent Corridor is expected to shift freight from congested highways, eliminating more than 1.3 million long-haul truck trips annually, which will save more than 169 million gallons of fuel and prevent 1.9 million tons of CO_2 emissions.

CONSOLIDATING SHIPMENTS

HP, Inc. merged the company's Less-Than-Truckload (LTL) and low-density truck shipments from ocean ports into full truckload intermodal shipments that maximize on the space available for goods and use a lower carbon mode for a greater portion of the trip. This effort helped HP, Inc. reduce greenhouse gas emission from operations by 13,000 tonnes (EPA, 2023).

A study by the Transportation Consortium of South-Central States demonstrated several benefits of truck freight consolidation, such as cost and emissions savings; highlighting widespread use of the practice could reduce national GHG truck freight emissions by 17% (Liu and Zhao, 2019).

LAST MILE ELECTRIFICATION

The logistics company DHL has converted the majority of their last-mile fleet to net-zero emissions vehicles, including electric delivery vans and several thousand e-bikes and e-cargo trikes. In a San Franscisco pilot, new electric delivery vehicles achieved over 60 miles per gallon (MPG) equivalency compared to 13 MPG for similar gasoline-powered vans (EPA, 2022).

In a study that estimated actual daily food deliveries from Hunts Point to retail stores in the Gowanus district in Brooklyn, New York, diesel trucks were shown to emit 40% more GHGs (on a lifecycle basis) than electric trucks, if electric trucks were driven instead (Elangovan et al., 2021).

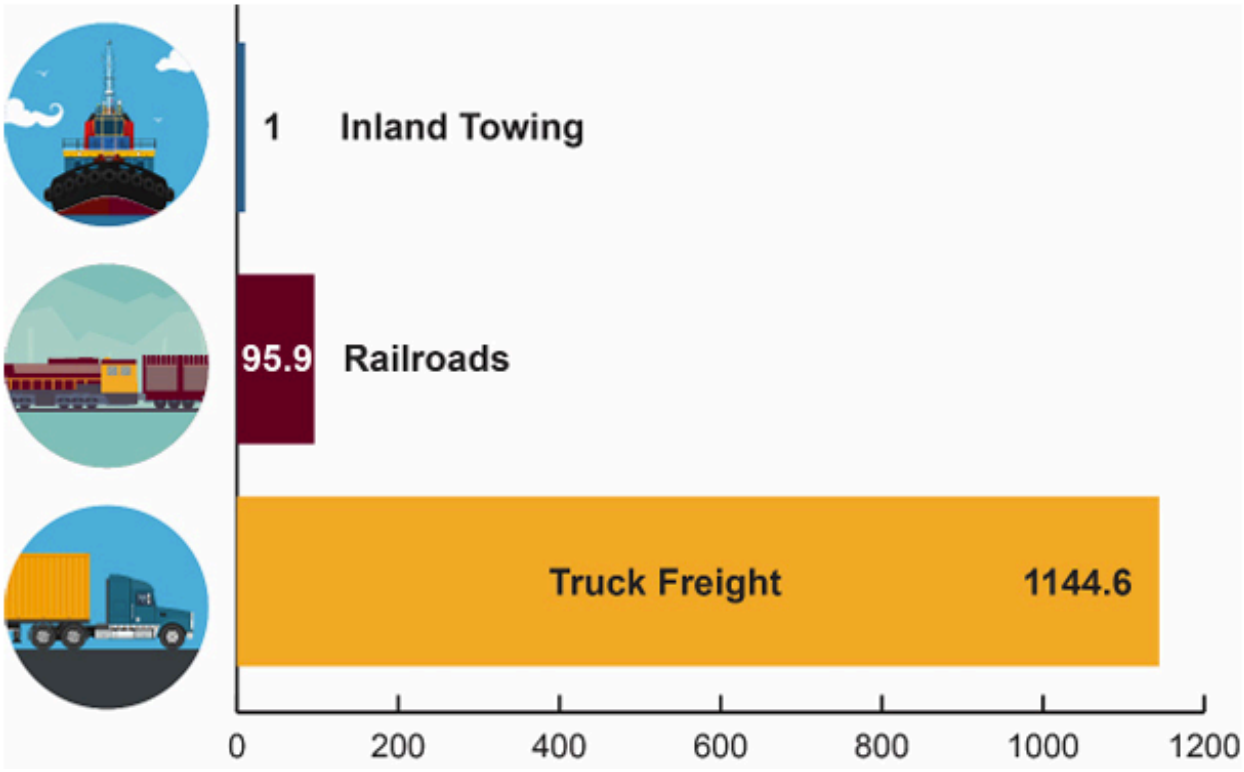
CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Shifting freight from roads to rail and water routes can reduce the frequency and severity of accidents and incidents, including hazmat-related incidents. A Texas A&M Transportation Institute comparison of fatalities by mode for 2001-2019 showed that truck freight resulted in 120 times more fatalities compared with inland towing and approximately 5 times more compared with rail (Kruse et al., 2021).

Removing goods movements by truck can lead to large safety improvements. Delivery vehicles are often large vehicles with poor sight lines, increasing the likelihood of striking vulnerable road users compared with smaller vehicles. In congested areas, delivery vehicles often block lanes of traffic and may block bike lanes and crosswalks, creating dangerous conditions for bicyclists and pedestrians (AIANY, 2022).



Ratio of Injuries per Billion Ton-Miles versus Inland Marine (2001–2019) (Kruse et al., 2021).

AIR QUALITY AND HEALTH

Diesel freight is responsible for significant amounts of particulate matter pollution and adverse health effects, particularly in communities living near highways and ports (EPA, 2020). Choosing to shift some freight transport to less carbon-intensive modes can reduce transportation-related air pollution.

The Columbia Slough Intermodal Expansion Bridge in Portland, Oregon was constructed to support more shipments by rail. It led to the following estimated emission reductions: 52 kg/day VOC, 241 kg/day CO, and 364 kg/day NOx (FHWA, 2017).

ECONOMIC GROWTH

Investment in rail can generate large economic returns. For instance, the new Norfolk Southern Crescent Corridor will handle more rail freight traffic and move the freight faster and more reliably. When fully operational in 2030, the corridor is expected to create over 122,000 jobs across the rail network and add new terminal facilities in Alabama, Tennessee, North Carolina, and Pennsylvania (Sugawara, 2017).

RURAL COMMUNITIES

Freight transportation plays a key role in rural economies. Outbound freight services allow rural industries and agricultural producers to sell their products in national and international markets, while inbound freight is used to obtain supplies, raw materials, and production equipment (NASEM, 2022).

Improvements to network efficiency and choosing less carbon intensive modes can reduce the impacts of freight transport on rural communities. Large volumes of freight either originate in rural areas or are transported through rural areas by road, rail, and waterways. Two-thirds of rail freight originates in rural areas, and nearly half of all truck vehicle miles traveled (VMT) occur on rural roads (USDOT, 2023).

ACCESSIBILITY AND EQUITY

Intermodal freight strategies can alleviate noise, air quality, and safety impacts to disadvantaged and vulnerable communities. For example, removing trucks from the road, careful planning of truck routes, and distribution facilities can distribute the benefits and burdens of freight routes more equitably (AIANY, 2022).

Analysis shows that new distribution hubs and shifting freight from trucks to maritime routes could help address inequal access to fresh food (i.e. "food deserts") in low-income communities in New York City (AIANY, 2022).

COST SAVINGS

The Norfolk Heartland Corridor routing slices more than 200 miles and nearly 24 hours off the previous double-stack routes between Norfolk, Virginia and the Midwest (FHWA, n.d.).

Investing in intermodal approaches can save companies and consumers money. Kimberly-Clark increased intermodal utilization by 120% from 2006 to 2013, saving an estimated $355 million (EPA, 2019).

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COST CONSIDERATIONS

The **Norfolk Southern Heartland Corridor**, completed in 2010, makes the most direct rail route to the major markets of Columbus and Chicago accessible to double-stack container trains. It extends through Virginia, West Virginia, Kentucky, and Ohio, consisting of a series of five separate intermodal projects designed to improve mobility and increase freight capacity. This project represents the first time that the private freight rail industry has worked together with USDOT (FRA, FTA, and FHWA) to develop and finance a rail improvement project. An investment of $93.2 million in public funding for the Central Corridor Double-Stack Initiative leveraged an additional $98.4 million investment from the private sector (FHWA, n.d.).

The **Columbia Slough Intermodal Expansion Bridge** was constructed for railroads to directly access a deep-water port facility, eliminating truck trips. The total cost of the project was $6.1 million, comprised of $1 million in Congestion Mitigation and Air Quality Improvement (CMAQ) Program funds, $2.1 million in demonstration funds, and $3 million in private funds (FHWA, 2017).

Norfolk Southern's Crescent Corridor is a program of improvements to infrastructure and other facilities geared toward creating a high capacity 2,500-mile intermodal route from New Jersey to Louisiana. In 2010, the program was awarded a TIGER grant in the amount of $105 million, split evenly towards the construction of two regional intermodal facilities in Tennessee and Alabama. The program of projects is estimated to cost $2.5 billion for full development, with completion expected in 2030 (Sugawara, 2017).

FUNDING OPPORTUNITIES

FRA's **Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program** funds projects that improve the safety, efficiency, and reliability of freight and intercity passenger rail. CRISI funds can be used for a wide variety of projects supporting the development of rail, ranging from capital investments to workforce development and training, to research and development, and more.

DOE's **Advanced Research Project Agency (ARPA-E)** is funding projects that develop technology to model the low-carbon intermodal freight transportation system of the future. The projects are expected to reduce emissions by enabling prioritization of low-carbon energy infrastructure deployment, along with data required for the effective deployment of this optimized distribution system.

MARAD's **Port Infrastructure Development Program (PIDP)** aims to improve port and related freight infrastructure through funding port improvements, including those with decarbonization and resilience co-benefits, in rural and urban areas nationwide. By improving maritime freight infrastructure, the PIDP improves the availability of maritime shipping and makes it a more viable option compared to higher-carbon modes of freight transport.

MARAD's **Marine Highway Program** supports projects that provide a coordinated and capable alternative to landside transportation by promoting marine highway transportation through the nation's navigable waterways. By developing and broadening crucial shipping corridors, the program offers an alternative to landside transportation corridors and higher-emission modes of freight transportation.

USDOT's **Rebuilding American Infrastructure with Sustainability and Equity (RAISE)** program provides funding for innovative capital projects, including critical freight infrastructure projects.

USDOT's **INFRA (the Nationally Significant Multimodal Freight & Highway Projects program)** awards competitive grants for multimodal freight and highway projects of national or regional significance to improve the safety, efficiency, and

reliability of the movement of freight and people in and across rural and urban areas. Eligible projects under INFRA include highway freight projects on the National Highway Freight Network, highway or bridge projects on the National Highway System highway, bridge, and freight projects on the National Multimodal Freight Network.

USDOT's **Transportation Infrastructure Finance and Innovation Act (TIFIA)** program provides credit assistance for qualified projects of regional and national significance. Many large-scale, surface transportation projects - highway, transit, railroad, intermodal freight, and port access - are eligible for TIFIA funding.

FHWA's **Congestion Mitigation and Air Quality Improvement** (CMAQ) provides a flexible funding source to States for transportation projects and programs to help meet the requirements of the Clean Air Act. Funding is available for transportation projects that reduce congestion and improve air quality for areas that do not meet the National Ambient Air Quality Standards for certain transportation related pollutants. Intermodal freight projects, including port projects, may be eligible under this program.

COMPLEMENTARY STRATEGIES

Digital solutions can support intermodal freight logistics through advanced tracking and scheduling systems and optimizing freight movements based on commodity, tonnage, and other factors.

Operational enhancements can improve the effectiveness of intermodal freight while reducing GHG emissions. For example, real-time tracking and data analytics can optimize intermodal routes, minimize transit times, and improve supply chain visibility. Automation and digitalization can streamline intermodal operations, reducing manual errors and delays.

By optimizing processes and using technology like automated scheduling or real-time tracking, intermodal freight operators can reduce idle times, improving overall efficiency and GHG reductions.

MICROMOBILITY DELIVERIES, MICROHUBS, AND LAST-MILE SOLUTIONS

Micromobility can complement intermodal freight by facilitating efficient distribution within urban areas, reducing GHG emissions by utilizing lower carbon modes for the last mile of the delivery.

OFF-PEAK DELIVERIES

Off-peak delivery, schedules support the freight industry in streamlining last mile deliveries which also leads to cost and efficiency savings.

View All Strategies

CASE STUDIES

STRATEGIC INTERMODAL SYSTEM (SIS) - FLORIDA

Source: Florida DOT, n.d.

The SIS was established in 2003 and encompasses transportation facilities of statewide and interregional significance with a focus on the efficient movement of passengers and freight. SIS objectives include interregional connectivity, intermodal connectivity, and economic development. There are currently 15 freight terminals in Florida, 6 of which are SIS-designated terminals which meet certain economic and efficiency criteria.

KIMBERLY-CLARK SMARTWAY PARTNERSHIP

Kimberly-Clark (K-C) joined EPA's SmartWay program in 2006 with goals that included reducing wait time and idling at shipping and receiving docks and increasing intermodal utilization. They developed an Intermodal Growth Strategy focused redesigning on a major distribution network and adding new distribution centers in markets to reduce dray mileage, as well as investing in a new Transportation Management System (TMS) to improve freight mode selection and increase intermodal opportunities. Between 2006 and 2013, K-C increased intermodal utilization by 120%, saved 62 million gallons of diesel, and reduced CO_2 by 630,000 metric tons.

URBAN FREIGHT AND LOGISTICS INITIATIVE - NEW YORK, NY

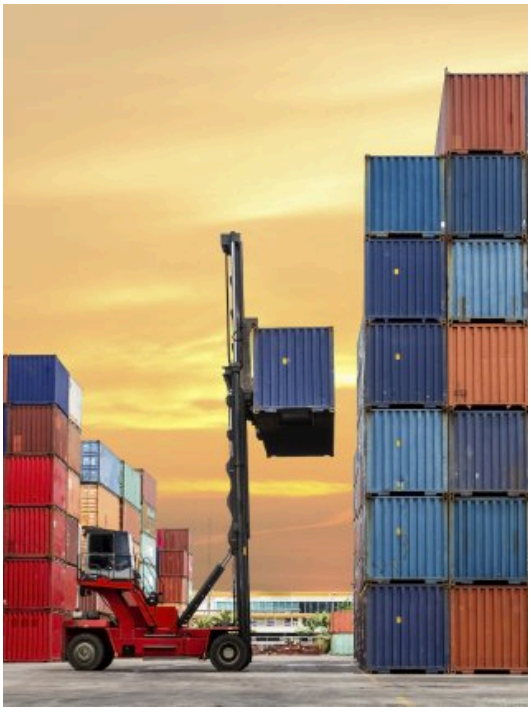
This initiative formed in 2022 with the goal of advancing freight policy in New York City by advocating for more efficient, equitable, and sustainable goods movement. The initiative's publication "Delivering the Goods: NYC Urban Freight in the Age of E-Commerce" lays out the current state of the practice of goods movement in NYC, describes potential system-scale and site-scale strategies, and provides recommendations with regarding to zoning and land use, street design, and other future work. The publication serves as a helpful reference for other cities and local communities, freight haulers, logistics companies, and other stakeholders impacted by freight.

Source: AIANY, 2022

IMPLEMENTING INTERMODAL AND MULTIMODAL FREIGHT PLANNING: **WHAT TO READ NEXT**

EPA's SmartWay Program helps advance supply chain sustainability and improve the environmental footprint and the efficiency of goods movement. SmartWay partners use and share best practices and innovative strategies and technologies that help to move goods more cleanly and efficiently through ports.

FHWA's Freight Mobility Trends and Highway Bottlenecks presents national freight statistics and identify freight highway bottlenecks on the Interstate System, National Highway System, National Highway Freight Network, and Strategic Highway Network.



Source: Environmental Protection Agency, SmartWay Program

Rural areas play an essential role in freight transport – outbound freight service delivers industrial and agricultural products to markets across the U.S., while inbound service provides raw materials. The National Academies' Rural Transportation Issues: Research Roadmap is designed to provide information and data to state transportation departments and other public agencies to help inform investment decisions, including freight planning.

The New York Chapter of the American Institute of Architects released "Delivering the Goods: NYC Urban Freight in the Age of E-Commerce" in 2022. The document provides an overview of freight-related challenges common to many cities and provides a wide range of system-scale and site-specific strategies to make goods movement more efficient, equitable, and sustainable.

FRA maintains a complete list of rail industry climate-related funding opportunities.

RESOURCES

GENERAL RESOURCES

FHWA and BTS Freight Analysis Framework: This framework, produced through a partnership between Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA), integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation.

FHWA Freight Mobility Trends and Highway Bottlenecks: This resource presents national freight statistics and identify freight highway bottlenecks on the Interstate System, National Highway System (NHS), National Highway Freight Network (NHFN), and Strategic Highway Network (STRAHNET).

ATRI Top 100 Truck Bottlenecks: This resource is an annual bottleneck list which provides a clear roadmap to guide investment decisions to address the nation's supply chain challenges. ATRI's bottleneck analysis incorporates and synthesizes several unique components, including a massive database of truck GPS data at freight-significant locations throughout the U.S., and a speed/volume algorithm that quantifies the impact of congestion on truck-based freight.

EPA's SmartWay Program: This program helps freight shippers, carriers, logistics companies, and other stakeholders reduce their environmental footprint, including reducing emissions of GHG and other pollutants. Organizations that share SmartWay's freight-efficiency goals and principles (e.g., non-profit organizations, air pollution control agencies, and state and local governments) may participate as a SmartWay Affiliate. SmartWay has developed a list of verified technologies and strategies to improve performance that save fuel and reduce emissions. The SmartWay Shiper Benefits Estimator helps estimate emissions reductions associated with using SmartWay technologies.

Freight Logistics Optimization Works (FLOW): This program, developed by USDOT, provides an industry forum combined with an information exchange platform to help address supply chain challenges and enable a resilient and globally competitive twenty-first century freight network. The collaborative forum will help the private and public sectors identify opportunities for operational efficiencies and mode choice in the nation's freight network.

EPA Ports Emissions Inventory Guidance: This resource provides guidance on emissions calculations for a variety of vessel, vehicle, and equipment types, including cargo handling equipment, harbor craft, onroad vehicles, and rail.

TOOLKITS AND MODELLING APPROACHES

National Level

US DOT Freight and Fuel Transportation Optimization Tool – Developed by the U.S. DOT Volpe Center, this is a flexible scenario-testing tool that optimizes the transportation of materials for energy and freight scenarios. The tool is designed to analyze the transportation needs and constraints associated with material collection, processing, and distribution to provide an optimal solution to supply chain routing and flows. FTOT can analyze a variety of commodities, datasets, and assumptions, and is customizable to each user's particular needs and questions.

US DOT Freight Logistics Optimization Works (FLOW): Developed by U.S. DOT, this tool provides an industry forum combined with an information exchange platform to help address supply chain challenges and enable a resilient and globally competitive 21st century freight network.

EPA Motor Vehicle Emission Simulator (MOVES): MOVES provides vehicle emission rates and mobile-source inventories, including data on intermodal equipment.

FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Emissions Calculator – Intermodal Freight: This tool estimates the emissions reduction from freight movements from highways to less carbon intensive modes.

Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model: The model provides life-cycle emissions assessment for different vehicle technologies and fuel types.

The Pacific Northwest National Laboratory (PNNL) decision-support tool: PNNL is developing a tool to evaluate the impact of present and future low-emission fuels on intermodal freight transportation with the goal of optimizing the fuel-mix deployment to minimize the cost of decarbonization. PNNL's innovative approach could reduce greenhouse gas emissions from the intermodal transit system by 60% by 2050.

State Level

California Quantifying the Effect of Local Government Actions on Vehicle Miles Traveled (VMT): This research resulted in a VMT Impact spreadsheet tool, which lets users easily see impacts for any census tract, city, or region in California

WORKING WITH COMMUNITIES

EPA Ports Initiative: This initiative works in collaboration with the port industry, communities, and all levels of government to improve environmental performance and increase economic prosperity. This effort helps people living and working near ports across the country breathe cleaner air and live better lives.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

OFF-PEAK DELIVERY

Off-peak deliveries ease traffic congestion and reducing unsafe interactions between delivery trucks and vulnerable road users, while promoting efficient and sustainable freight practices.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban

Truck deliveries during peak periods can worsen traffic congestion, which can lead to idling, increased greenhouse gas emissions, and air pollution. Curb-side deliveries require that drivers spend time searching for parking (increasing vehicle miles traveled (VMT) and emissions) and when nearby parking is not available, drivers may be forced to park illegally across multiple spots and lanes. This behavior can impede the flow of traffic for passenger and transit vehicles, further contributing to increases in VMT and emissions. **Off-peak delivery (off-hours delivery) programs encourage delivery companies and receiving businesses to shift to evening or overnight deliveries.** These programs can increase the productivity of freight operations, decrease truck traffic, and reduce freight-related environmental impacts. Diesel trucks emit a disproportionate amount of traffic-related air pollutants, particularly during stop-and-go conditions and idling – shifting deliveries to off-hours can significantly reduce emissions.

Less truck activity during peak periods can also make roads safer for cyclists and pedestrians, who are more likely to be using roads during day-time hours.

Off-peak deliveries can reduce interactions between trucks and vulnerable road users and encourage walking and biking over car use. Businesses can also benefit from off-peak deliveries through faster unloading times, easier access to storefronts for customers, and less idling and emissions from delivery trucks.

Off-peak deliveries can be made through traditional assisted delivery (i.e., people in business available to receive delivery), or via delivery lockers or staging areas, which do not require direct access to the store. Curb management systems can be designed to encourage off-peak deliveries by allowing for free or lower-cost parking during specific periods. Road usage charges and other pricing strategies, which typically charge drivers higher tolls or per-mile fees during peak periods, can also encourage delivery to shift to off-peak hours.

Did you know?

During a New York City off-hour pilot program, delivery speeds in Manhattan increased by 50% during off-hours compared with morning (8 am to 10 am) and by 130% as compared to midday (10 am to 4 pm) and evening (4-10 pm) (NYCDOT, 2019).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

Off-peak delivery programs consist of three interconnected components:

Nighttime and Evening Delivery Windows

Business and Delivery Station Adaptation

Businesses and delivery stations play a crucial role in off-peak programs by:

- Adjusting Receiving Hours: Shifting receiving operations to accommodate evening or overnight deliveries creates a more flexible and efficient system.
- Investing in Nighttime Operations: Some businesses may need to invest in additional lighting or security measures to facilitate safe nighttime operations.

Incentivizing Off-Peak Delivery

Programs and regulations can encourage wider adoption of off-peak delivery practices, including:

- Financial Incentives: Discounts, subsidies, or tax breaks for businesses and delivery companies that utilize off-peak delivery windows.
- Congestion Pricing: Imposing higher tolls or fees on daytime deliveries in congested areas can encourage a shift towards off-peak options.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

REDUCING EMISSIONS FROM DELIVERY TRUCKS

In a forthcoming modeling study, Argonne National Laboratory analyzed the effect of increasing off-peak deliveries in Chicago. Just a small fraction (5%) of businesses currently accept deliveries very early in the morning or at night. With a larger share (15%) of businesses accepting deliveries during these hours, delivery trips saw less idling and traffic congestion, leading to systemwide increases in delivery speeds of up to 8.6% (Auld et al., 2024).

A 2018 study used GPS data collected from delivery trucks in three U.S. cities to analyze the effect of off-peak versus regular-time deliveries on emissions. Off-peak delivery was found to reduce emissions by 13% to 67% compared to regular, peak periods (Holguín-Veras et al., 2018).

CITY-SPECIFIC OFF-HOURS PROGRAMS

Off-peak delivery in the Greater Toronto area could result in over 5,500 vehicle-hours saved per day, with light truck carriers benefiting the most by shifting to off-peak hours (Chowdhury et al., 2022).

Trucks represent about 10% of the Chicago region's traffic and 67% of the region's total freight volume. On several corridors where truck volumes are over 10,000 per day, congestion during morning peak periods increases travel times by an average of 60% (LaBelle and Frève, 2016).

A 2007-2010 New York City off-hour delivery pilot involved 33 food delivery companies that switched deliveries to between 7:00 pm and 6:00 am (Holguín-Veras et al., 2011).

- Average travel speeds for a key carrier-customer pairing increased by over 70% from 11.8 mph to 20.2 mph.

- A truck traveling for 10 miles making deliveries could save 1.25 hours of travel time due to increases in average speed from approximately 4 mph during regular hours and 8 mph during off-hours. The average fuel consumption rate and total emission rate during off-hours were found to be significantly lower than those during regular hours for the same segment. The differences were generally larger than 20% for highway and toll road segments, and over 50% for urban arterial road segments.
- The off-hours pilot also resulted in congestion and pollution savings for regular-hour road users. If about 20% of the deliveries in Manhattan were shifted to the off-hours, each receiver would be responsible for an annual reduction of about 551 vehicle miles traveled and 195 vehicle hours traveled.

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Off-peak delivery programs reduce congestion during peak periods and improve road safety by reducing conflicts between trucks, passenger cars, cyclists, and pedestrians (Sánchez-Díaz et al., 2017).

Increased nighttime noise may be a concern for residents but can be mitigated with low-noise strategies and equipment, driver training, and enforcement (Holguín-Veras et al., 2014). The New York City Off Hours Delivery Program is promoting use of quiet delivery practices for both the drivers and receivers and the use of low noise delivery equipment, such as electric door motors, hydraulically operated ramps, and electric refrigeration units (NYCDOT, 2024b).

COST SAVINGS

Parking fines in New York City average $500-1,000 per truck per month for regular-hour deliveries, a portion of which companies may pass onto consumers. Since it is easier for drivers to find legal parking spaces near their delivery locations during the off-hours, every off-hour delivery route that replaces a regular-hour route saves about $9,000 per off-hour delivery tour in annual parking fines (Holguín-Veras et al., 2013).

Another study found that shifting deliveries to off-hours can result in 20-30% overall cost savings for businesses (Holguín-Veras et al., 2011).

During a New York City pilot program, every delivery tour that switched from regular to off-hours saved the carriers, on average, $212.50 per day or $42,500 per off-hour delivery tour annually (Holguín-Veras et al., 2013).

Trucks entering New York city can take advantage of off-peak pricing on the NY/NJ Port Authority bridges and tunnels. For example, 2-axel delivery trucks pay different tolls depending on time of day and save around 12% by entering New York overnight.

ECONOMIC GROWTH

Off-peak delivery offers cost savings to both carriers and business establishments, while decreasing the harmful economic effects of congestion and pollution (Holguín-Veras et al., 2011).

The New York City off-hour delivery pilot showed that economic benefits of a full implementation of the off-hour delivery program are in the range of $147 to $193 million per year, corresponding to savings on travel time and environmental pollution for regular-hour traffic as well as productivity increases for the freight industry (Holguín-Veras et al., 2011).

ACCESSIBILITY AND EQUITY

Off-peak delivery has the potential to open up additional curb and sidewalk space during daytime hours, which can make it easier for pedestrians to access storefronts and other local establishments (NYCDOT, 2019)**.**

Off-peak delivery programs can reduce travel times for all road users, including bicyclists and pedestrians.

Off-peak programs can be implemented in conjunction with street design improvements, such as creating complete streets and heavily restricting vehicle access (e.g., off-peak delivery or emergency vehicles only). Re-allocating road space and priority away from private vehicles improves the safety and comfort for all road and public transit users (Yanocha, 2021).

RURAL COMMUNITIES

While competition for curb space is particularly intense in metropolitan areas (Burnell et al., 2017), rural downtown districts can face many of the same challenges related to availability of loading areas and congestion during peak periods.

Large volumes of freight either originate in rural areas or are transported through rural areas by road, rail, and waterways. Two-thirds of rail freight originates in rural areas, and nearly half of all truck vehicle miles traveled (VMT) occur on rural roads (USDOT, 2023). Improvements to network efficiency and choosing less carbon intensive modes can reduce the impacts of freight transport on rural communities.

Many warehouses and manufacturing facilities that support urban freight deliveries are also located in rural areas. Shifting deliveries to off-peak hours can benefit rural communities through reduced traffic and emissions.

AIR QUALITY AND HEALTH

Off-peak delivery decreases incidence of truck idling and decreases truck-related congestion during peak hours. Reduced truck idling and congestion also reduces idling and congestion for other classes of vehicles.

Diesel freight is responsible for significant amounts of particulate matter pollution and adverse health effects, particularly in communities living near highways and ports (EPA, 2023).

Shifting approximately 20% of deliveries in New York City to off-hours results in significant pollution reductions: over 200 metric tons of carbon monoxide, approximately 12 tons of NOx, and 70 tons of PM10 annually (Holguín-Veras et al., 2014).

Higher speeds during off-peak hour deliveries resulted in lower emissions during an Ontario, Canada pilot program. Total CO_2 emissions per kilometer decreased by 10.6%, and emissions for air pollutants, including CO, NOx, PM10 and PM2.5, decreased by 10 to 15% (Mousavi et al., 2020).

COST CONSIDERATIONS

The cost to implement off-peak delivery varies widely depending on the scale, scope, and location of the project

Financial incentives for both goods carriers and receivers can encourage more deliveries to occur during off-hours. These may include one-time or annual payments, tax credits, and less expensive parking for off-hours deliveries.

Results from the New York City off-hours delivery pilot show that a one-time financial incentive of $10,000 to $15,000 per year can maximize program benefits. This amount helped divert 14 to 21% of total truck traffic in Manhattan during the pilot period (Holguín-Veras et al., 2011).

For example, the NYC off-hour delivery Incentive Program is providing up to $1.5M in one-time incentive payments to businesses that participate in Phase I of the expanded off-hours program. Incentives can be used towards access enhancements, security equipment, low-noise cargo handling equipment, and green delivery methods (e.g. cargo bikes, EV vans) (NYCDOT, 2024a; NYCDOT, 2019).

When delivery sites are located within or adjacent to residential areas, off-peak programs may increase noise pollution during overnight hours. Increased noise may result in additional costs to companies, including costs related to noise mitigation technologies and strategies, driver training, and using longer alternative routes (Holguín-Veras et al., 2018; NYCDOT, 2019).

Adopting off-peak hours may result in labor impacts on delivery drivers and receiving customers, as well as warehouses and distributors. Off-peak operations require customers to stay late to receive goods and supply chain partners to adopt off-peak operations. Extended and overnight hours may increase the cost of goods delivery in an area. However, previous pilot studies (New York City, Belgium, Peel) and behavioral studies have largely shown that extra labor costs are balanced by cost savings due to increased productivity and fewer parking violations (Holguín-Veras et al., 2018; Verlinde et al., 2011; Mousavi et al., 2020).

A pilot study in Peel, Australia asked participants specifically about added logistics costs and found that no additional costs were incurred as a result of the off-peak delivery pilot. One participant noted that their distribution centers already ran overnight shifts prior to the pilot and that retail stores were able to accommodate the after-hours staffing costs (Mousavi et al., 2020).

For costs related to establishing pricing programs and curb management programs, see the Road Pricing and Parking Reforms pages.

FUNDING OPPORTUNITIES

FHWA's **Congestion Relief Program,** established under the Bipartisan Infrastructure Law (BIL), provides competitive grant funding for programs that reduce congestion through pricing roadway use and parking, among other methods of decreasing congestion. This includes supporting activities that reduce or shift highway users to off-peak travel times or to nonhighway travel modes during peak travel times.

FHWA's **National Highway Freight Program (NHFP)** is aimed at improving the efficient movement of freight on the National Highway Freight Network (NHFN). The program supports investment in infrastructure and operational improvements that strengthen economic competitiveness, reduce congestion, reduce the cost of freight transportation, improve reliability, and increase productivity.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Delivery/logistics is included as a technology area for eligible projects.

COMPLEMENTARY STRATEGIES

The relationship between freight digitalization and off-peak delivery is increasingly intertwined, with digital technologies playing a pivotal role in enabling and optimizing off-peak delivery strategies. For example, freight digitalization strategies, such as real-time tracking systems and predictive analytics, allow logistics operators to optimize delivery routes and schedules, identifying opportunities for off-peak delivery based on factors like traffic patterns, delivery windows, and customer preferences. In addition, curb reservation systems, common carrier lockers, and other technological solutions can facilitate deliveries during off-peak hours.

Integrating micromobility deliveries with off-peak delivery can enhance the overall effectiveness of freight movement and avoid greenhouse gas emissions. Off-peak delivery times can alleviate congestion and improve efficiency for micromobility deliveries.

Off-peak delivery is one potential component of multimodal and intermodal freight planning that supports freight sector climate goals.

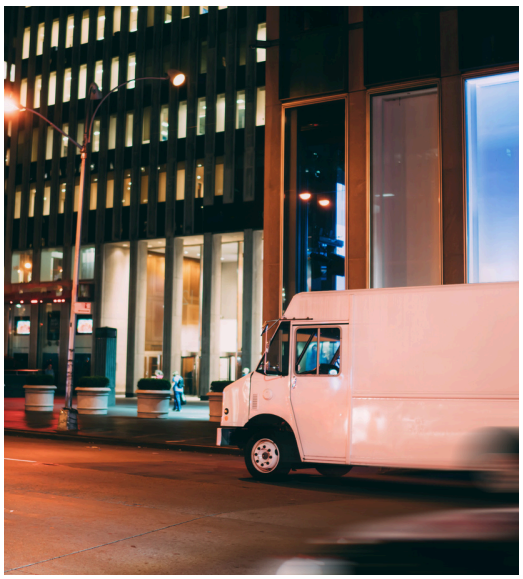
Parking reform initiatives, such as adjusting parking regulations, implementing dynamic pricing, creating dedicated loading zones, or other curb management approaches can influence the availability of curb space for commercial vehicles during non-peak hours. By reallocating parking spaces or implementing flexible parking policies that prioritize loading and unloading activities during non-peak times, communities can create more opportunities for off-peak deliveries without causing congestion or disrupting traffic flow.

Road usage charges and other pricing programs that charge higher tolls during peak hours may encourage carriers to shift deliveries to off-peak hours.

View All Strategies

CASE STUDIES

NEW YORK CITY OFF-HOUR DELIVERIES PROGRAM



The New York City DOT piloted an Off-Hour Deliveries (off-hour delivery) Program from 2007 to 2010 which was funded by USDOT and run in partnership with the Rensselaer Polytechnic Institute, Rutgers University, ALK Technologies, and New York University. Over 300 participants across 400 business locations agreed to shift delivery times from peak hours (between 7 am to 4 pm. to off-peak hours (between 7 pm and 6 am). As a result of the program, delivery speeds in Manhattan increased by 50% during off-hours compared with morning (8 am to 10 am) and by 130% as compared to midday (10 am to 4 pm) and evening (4-10 pm). The average service time at each individual stop was 30 minutes during off-hours, while drivers spent roughly 3 times longer at each stop during the day due to longer walks, wait at freight elevators, and other sources of delays. Due to the success of the pilot program, the DOT permanently adopted off-hour delivery in 2017 and expanded to additional retailers and delivery areas.

GREATER TORONTO AREA OFF-PEAK DELIVERY IMPACTS

A recent study in the Greater Toronto Hamilton Area (GTHA) analyzed traffic surveys and commercial vehicle counts to generate a model that could estimate the impacts off-peak deliveries. If 30% of freight carriers participated in off-peak deliveries, total daily travel time savings would exceed 5,500 vehicle hours. A similar modeling approach could be applied to other cities and regions to evaluate the benefits of implementing a off-peak hours policies and programs.

IMPLEMENTING OFF-PEAK DELIVERY: **WHAT TO READ NEXT**

Primers on Off-Hours Delivery

FHWA's Primer for Improved Urban Freight Mobility and Delivery includes a spotlight on off-hour delivery, including results from a logistics pilot in Stockholm, Sweden.

Researchers at the University of Stockholm provide a helpful comprehensive review paper on off-hours delivery programs: Shifting Urban Freight Deliveries to the Off-Peak Hours: A Review of Theory and Practice.

Jurisdiction of curb space typically falls under State, regional, or local agencies. To encourage State and local agencies to implement better curbside management strategies, DOTs can designate funding, include provisions in existing programs, or develop pilot programs that support curbside management. See findings from the New York City Off-Hours Delivery Pilot as an example.

Large Businesses Can Lead the Way

In New York City, it is estimated that large traffic generators (LTGs), including large buildings or landmarks and large establishments, generate approximately 4-8% of Manhattan's total truck traffic (Holguín-Veras et al., 2013).

- LTGs are a convenient target for off-hours programs, as managers can help coordinate deliveries and facilities tend to be well equipped to receive both staffed and unassisted deliveries (Jaller et al., 2015).
- LTGs will often have centralized delivery stations, which can receive deliveries during off-peak hours and then forward them to businesses during normal operating hours (Holguín-Veras et al., 2013; Jaller et al., 2015).
- Larger establishments (more than 250 employees) and buildings with many businesses yield the greatest savings in terms of the number of truck trips and cost-effective implementation, as additional costs can be shared among more customers (Holguín-Veras et al., 2013).
- The are over 182,000 estimated freight trips attracted (FTA) in Manhattan each day. Approximately 84% of the daily FTA is attributable to large establishments (Jaller et al., 2015).

Facilitating Unassisted Deliveries

Some recipients may not be able to receive deliveries at night – for example, due to storage space, personnel costs, and liability/security. Unassisted off-hour deliveries may help address these concerns. Options for unassisted programs include keyless entry system, DVR devices for access and internal surveillance, and insurance coverage provided by carriers (Holguín-Veras et al., 2013).

RESOURCES

GENERAL RESOURCES

National Level

DOE INcreasing Transportation Efficiency and Resiliency through MODeling Assets and Logistics (INTERMODAL) Exploratory Topic: The DOE funded various intermodal freight projects focused on developing tools and frameworks to support low-carbon intermodal freight transportation systems. Project highlights are available.

FHWA Primer for Improved Urban Freight Mobility and Delivery: The primer includes a spotlight on off-hour delivery, including results from a logistics pilot in Stockholm, Sweden.

University of Washington Urban Freight Lab: The lab is a public-private partnership with research goals that include reducing GHG from urban freight transportation and increasing urban freight efficiency.

Shifting Urban Freight Deliveries to the Off-Peak Hours: A Review of Theory and Practice: A review paper on off-hours delivery programs.

FHWA Tolling and Pricing Resources:

- Center for Innovative Finance Support
- Office of Operations
- Congestion Pricing

State and Local Level

American Institute of Architects New York Chapter (AIANY). 2022. Delivering the Goods: NYC Urban Freight in the age of E-Commerce: The publication provides details of the state of urban freight in New York City with the growth of e-commerce. The resource explores challenges, scenarios, and design considerations to move goods efficiently across the city.

New York City Off-Hour Deliveries Pilot: The resource provides high-level findings and follow-on Smart Truck Management Plan which covers a range of strategies including off-hours deliveries, providing better access to the curb, innovative delivery methods, and improved truck routing.

TOOLKITS AND MODELLING APPROACHES

DOE Argonne National Lab's POLARIS Transportation Simulation Tool: The tool can be used to model various travel and freight scenarios. Auld (2024) used POLARIS to evaluate the impacts of off-hours delivery on traffic conditions in Chicago.

EPA Motor Vehicle Emission Simulator (MOVES): MOVES can be used to generate per-mile and per-hour emission rates for delivery trucks and estimate emission reductions as a result of off-hour programs.

Freight Analysis Framework (FAF): The FHWA and BTS database contains freight flow data sourced from a variety of sectors to support freight analysis and inform decision-making. The database provides a comprehensive summary of current freight trends and can be used to predict future trends.

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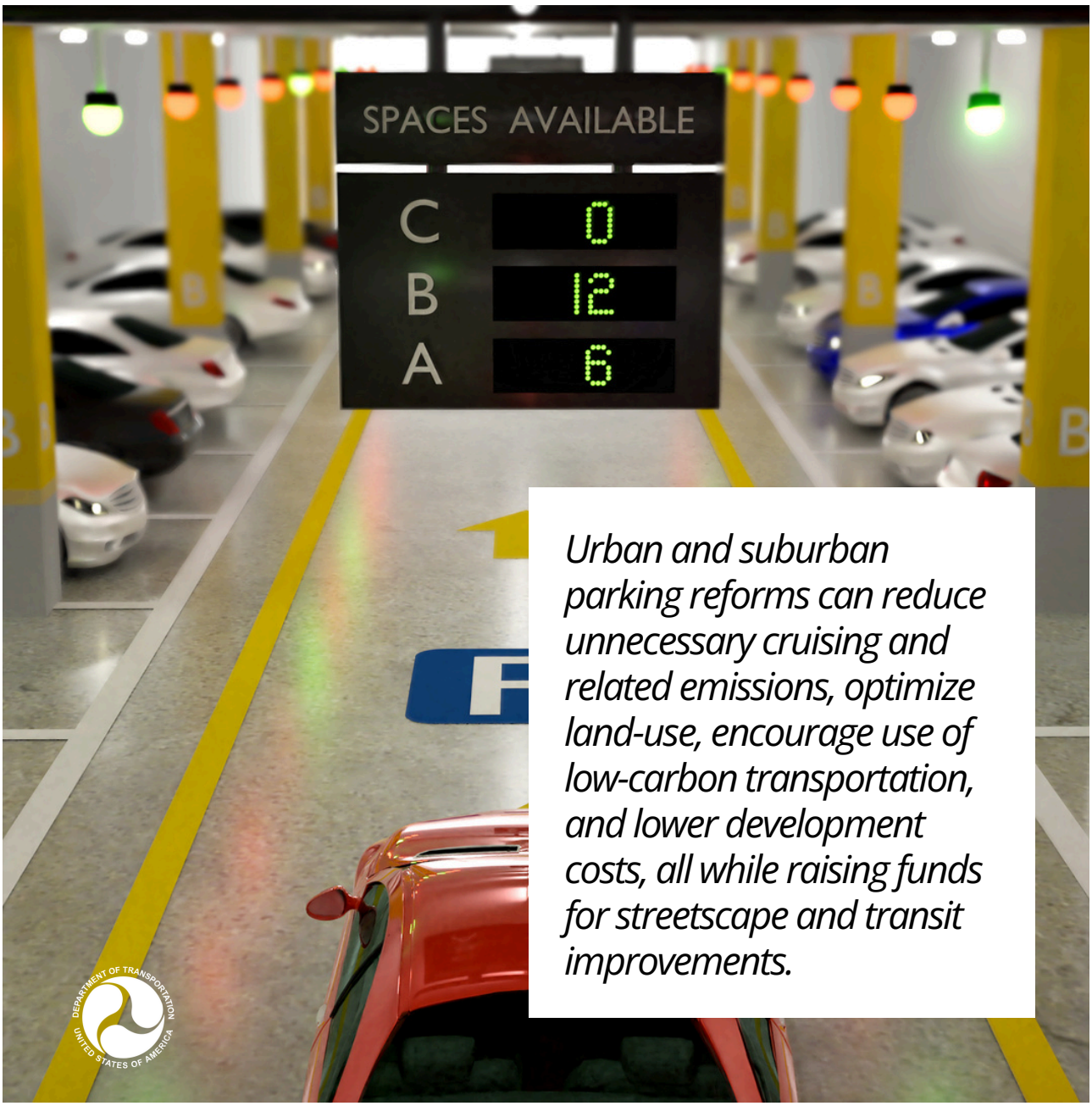
U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

PARKING REFORMS



Urban and suburban parking reforms can reduce unnecessary cruising and related emissions, optimize land-use, encourage use of low-carbon transportation, and lower development costs, all while raising funds for streetscape and transit improvements.

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OVERVIEW

Best Suited for:
Short term*
Urban, Suburban

Parking reforms are designed to **efficiently use the existing parking supply and better balance supply and demand.** By reducing the time spent searching for parking, also known as cruising, parking reforms can reduce congestion and greenhouse gas (GHG) emissions**.** Parking reforms can also be designed to discourage driving to certain areas during peak periods and support safe and convenient access through walking, biking, and public transit.

In the United States, there are three to eight parking spaces for every car (Goldstein, 2015). In many cities, the area of required parking for a building exceeds the area of the building itself and the scale of land utilized for parking presents a barrier to walkable communities, transit-oriented development, and active transit. **Zoning changes can reduce the amount of land designated for parking and encourage walking, biking, and public transit.** For example, eliminating parking minimums decreases the number of parking spaces that must be included with new developments. Similarly, parking caps set a maximum number of parking spaces allowed for development projects. Unbundling parking from rent or ownership reduces costs for transit users and others without a car by allowing residents to only pay for parking if needed. Other strategies, such as shared parking facilities and in-lieu fee parking, aim to take advantage of varying peak demand timing for different destinations (such as a bank versus a church) to maximize parking efficiency. When implemented in conjunction with strategies that restrict free on-street parking and improve access to transit, **these reforms can improve choice across transportation modes and reduce the number of unused parking spaces.**

Smart parking systems use sensors to make the location and number of parking spaces easily identifiable to drivers to reduce cruising. Sensor-based technologies can also supply data to parking pricing programs. Demand-responsive or performance-based pricing programs involve setting parking prices based on the demand at given times to maximize use while maintaining a few open spaces (often with an aim of 70-85% use). This dynamic pricing model has

*Pilot or initial roll out in certain area followed by full implementation.

been shown to reduce congestion and related emissions by both reducing cruising and encouraging walking, biking, and transit trips. When coupled with smart parking, dynamic pricing can increase ease of finding a parking spot. Furthermore, revenue from dynamic pricing, in-lieu fees, and parking benefit districts can be reinvested in the community for transit, streetscapes, and business improvements, which supports vibrant communities and safe streets.

With many different strategies available to reform parking, communities should choose what best fits their needs. ***Examples of parking reforms include:***

Zoning Changes

- Eliminating parking minimums
- Parking maximums
- Shared parking facilities

Smart Parking

- Meters
- Apps
- Sensors with lights or signage highlighting the availability of spaces

Parking Fees

- In-Lieu fee parking
- Demand or performance-based pricing
- Unbundling parking from rent or ownership
- Parking benefit districts
- Charging for parking (on-street and off-street)

Repurposing

- Low- and Zero-Emission Zones
- Open Streets

Did you know?

In California, researchers showed that unbundled parking contributed to a decrease in rent by around $200 a month and lower condo sale prices by around $43,000 (Manville, 2013).

GHG REDUCTION POTENTIAL

This section provides an overview of GHG emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

ELIMINATING EMISSIONS DUE TO CRUISING

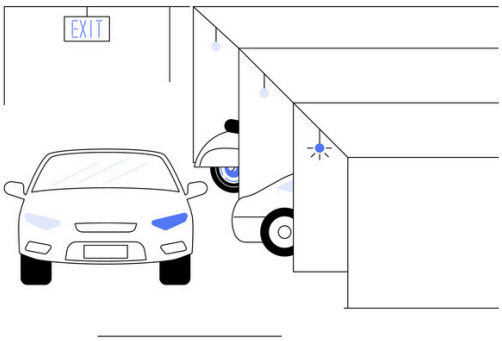
Free or underpriced public parking encourages people to drive to their destination and once at the destination, to circulate to find an unoccupied spot (ITDP, 2021).

The pilot program of SFPark, a demand-responsive parking program in San Francisco, resulted in a 30% decrease in vehicle miles traveled (VMT) in SFPark areas (Jose, 2017).

In a 15-block radius in Los Angeles, researchers estimated that cruising resulted in an excess 950,000 miles in one year, which is equivalent to 47,000 gallons of gas and 730 tons of CO_2 emissions (Shoup, 2007).

A study examining cruising rates in numerous U.S. studies found that 4-6% of trips in Ann Arbor and 4.5-8.9% of trips in Seattle resulted in cruising (Weinberger et al., 2023).

In Cologne, Germany, after the installation of a Smart Parking overhead sensor system, test drives demonstrated that cruising time decreased by 45% (CleverCiti Systems, 2020).



REDUCING CAR RELIANCE

A 2021 study of affordable housing in San Francisco demonstrated that household car ownership increased with the availability of on-site parking. Decisions related to transportation mode were correlated with parking availability, indicating that reducing excess parking may lessen incentives for household car dependency given options for car-free and car-light modes, such as public transit and walking (Millard-Ball et al., 2021).

A study from New York City found that people with guaranteed parking at home were more likely to use a car for commuting to work even when both the origin and destination were well served by transit (Weinberger, 2012)

LIMITING PARKING SUPPLY AND UNBUNDLING PARKING COSTS

A study by the California Air Pollution Control Officers Association (CAPCOA estimates that reducing the total parking supply available at a residential site (without unrestricted street parking or other offsite parking) can reduce GHG emissions from resident vehicles by up to 14% (CAPCOA, 2021).

Unbundling or separating a residential project's parking costs from property costs requires residents to purchase parking spaces at an additional cost. Unbundling parking costs can incentivize public transit use and reduce vehicle use during peak periods, providing up to a 15% reduction in GHG emissions (CAPCOA, 2021).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

High car use in residential areas makes those neighborhoods less safe for walking and biking, especially for children, seniors, and people with disabilities who may be harder to see from a car. Behaviors like cruising for parking and double parking can have significant adverse effects on roadway safety for people walking and biking (Sha et al., 2024).

Removing on-street parking can allow communities to repurpose this space for uses that improve safety, such as protected bike lanes or expanded sidewalk space.

ECONOMIC GROWTH

Parking reforms reduce barriers for businesses to open. In Auburn, Maine, a town of 24,000 people, new restaurants opened after parking minimums were eliminated. The parking reforms allowed businesses to open in existing sites without constructing additional parking, reducing barriers to entry for a new business. (Spivak, 2022).(Spivak, 2022).

> After Buffalo and Seattle eliminated parking minimums, more than half of the new homes constructed would have been illegal under the previous parking mandates. Parking reforms encourage the construction of affordable and high-density housing, including reduced construction costs and barriers to renovate existing buildings into housing (Gould, 2023).

A study in Colorado modeled the impact of removing parking minimums in urban municipalities and found that this would increase housing supply and shift housing development opportunities towards infill and transit-oriented locations. The study found that removing parking minimums would lead to 71% more homes in transit-oriented areas, and 41% more homes overall in the urban areas studied (Sightline Institute, 2024).

ACCESSIBILITY AND EQUITY

Setting lower parking minimums reduces development costs as less parking must be constructed. In turn, this increases the profitability of projects which encourages more affordable housing.

Required parking minimums disproportionately increase the cost to build low-income housing, since parking costs are the same for different sizes and types of housing. One study found

that minimum parking requirements raise housing costs by 13 percent for families without cars (Shoup, 2020).

Requiring one parking space per unit in affordable housing developments increases rent by 12.5% on average (VIA Architecture, 2015).

In California, researchers showed that unbundled parking contributed to a decrease in rent by around $200 a month and the cost of a condo by around $43,000 (Manville, 2013).

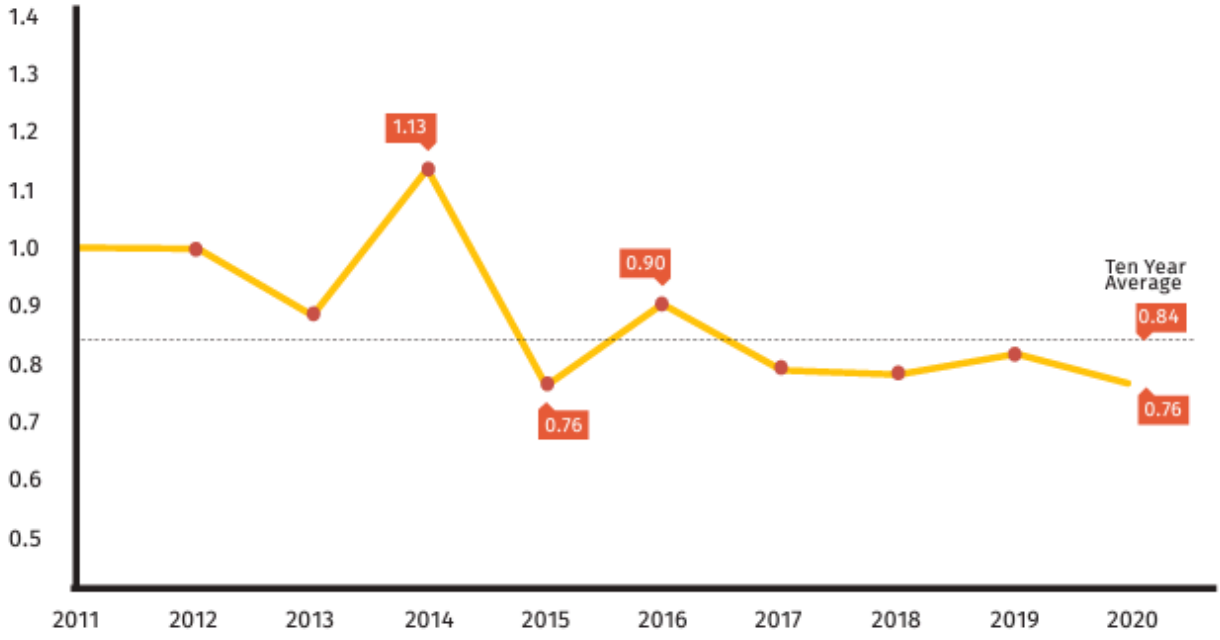
After Minneapolis, Minnesota reduced the parking minimum requirement for multifamily housing, planners identified that developments included fewer parking spaces and rent prices in some areas dropped by almost 17% (Spivak, 2018).

Means-based discounts, subsidies, caps, and exemptions can help reduce the burden of parking cost increases (Portland Bureau of Transportation, 2020).

Portland, Oregon implemented three-hour parking for the price of two hours for blue-zone accessible parking in certain metered areas (Portland Bureau of Transportation, n.d.).

Austin, Texas offers an Affordable Parking Program that allows members of the service or entertainment industry to apply for a reduced-cost monthly parking pass in downtown garages (City of Austin, n.d.).

The change in parking spaces per residential unit in Minneapolis from 2011 to 2020 (Source: ITDP, 2024)



JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

RESILIENCE AND ADAPTATION

Parking reforms can reduce the amount of space needed for parking, contributing to more dense developments which can help preserve open green space to mitigate flooding or heat impacts.

Surface parking lots contribute to the heat island effect, where urban areas become "islands" of higher temperatures due to pavement and other infrastructure absorbing the sun's heat.

AIR QUALITY AND HEALTH

On average, U.S. drivers waste 17 hours annually cruising for parking. In New York City, this number is 107 hours. The extra time drivers spend cruising adds additional cars to the road, increasing roadway congestion and producing greenhouse gas emissions and other air pollutants (Cookson & Pishue, 2017).

> During the first two years of the pilot program, researchers estimated that SFPark, a demand-responsive parking program in San Francisco, reduced cruising time by 50% when compared to neighborhoods outside of the pilot (Millard-Ball et al., 2014).

RURAL COMMUNITIES

Rural communities can yield the same benefits from parking reforms as urban and suburban communities. For example, reduced construction costs from the elimination of parking minimums removes barriers for businesses to open. Over 900 towns with 100 to 5,000 residents have passed or implemented parking reforms town-wide or in the town center as of Summer 2024 (Parking Reform Network, 2024).

COST SAVINGS

Eliminating parking quotas reduces construction costs, particularly for new housing developments. Parking pricing reduces public subsidies for privately parked vehicles and generates revenue to support transportation infrastructure as well as other community and construction development projects.

The cost to construct a parking space is estimated to be $5,000 for surface-level parking and up to $50,000 for multi-level garages (Spivak, 2022).

Parking reforms, including eliminating parking minimums for multifamily housing near high-frequency transit, were implemented in Seattle, Washington in 2012. In the five years following this zoning change, researchers found that 40% less parking was constructed, saving around $537 million (Gabbe et al., 2020).

COST CONSIDERATIONS

The cost to implement parking reforms varies widely depending on the scale, scope, and location of the project.

> **Smart parking meters cost between $250-$500** each and **ultra-sonic parking space availability sensors cost $300-$500** per space to install (CBS58 News, 2017; Roos, 2017).

In less than 2 years of operation, a Smart Parking overhead sensor system in Cologne, Germany led to an 8% increase in utilization of existing parking spaces, reducing the demand for new or on-street parking, and allowed the city to realize a complete return on investment (CleverCiti Systems, 2020).

The median percentage of land used only for parking is approximately 26% in the downtown of American cities with populations greater than 500,000 people. In urban environments, space used for parking, particularly when parking is free, has a higher potential for tax revenue from other uses (Carpenito, 2023).

One study estimated that implementing a smart parking system in Houston, Texas would generate $82 million to $722 million in surface parking redevelopment value, which in turn would increase tax revenue by $575,000 to $4.7 million annually (Huntsman et al., 2018).

FUNDING OPPORTUNITIES

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** established under the Bipartisan Infrastructure Law (BIL), provides grant funding to eligible public sector agencies to carry out projects improving transportation efficiency and safety through smart technologies. Smart parking projects using sensors may be eligible.

FHWA's **Congestion Mitigation and Air Quality Improvement program (CMAQ)** provides a flexible funding source for States to meet the requirements of the Clean Air Act through transportation projects. Funding is available in certain current and former non-attainment and maintenance areas for projects that can include some parking management strategies.

FHWA's **Congestion Relief Program** established under BIL, provides competitive grant funding for programs that reduce congestion through pricing roadway use and parking, among other methods of decreasing congestion. This would have the benefit of encouraging other modes of travel that pollute less and take up less road space, while recapturing some of the value associated with road maintenance and construction from those who use the roads most.

FTA's **Capital Investments Program** funds transit capital investments, including heavy rail, commuter rail, light rail, streetcars, and bus rapid transit. CIG grants can be used to support public transit improvement potentially in concert with revenues from parking pricing programs.

COMPLEMENTARY STRATEGIES

Enhanced commuter benefits for employees that walk, bike, or take public transit provide a viable alternative to driving and parking at work.

Coordinated transportation planning and parking reform are interconnected in shaping travel behavior, mobility, and reducing GHG emissions. When coordinated transportation planning integrates with parking reform strategies, it can encourage the use of alternative modes, such as public transit, biking, or walking, making driving and parking only one of several options for trips.

Free or reduced fare transit programs and parking reform are complementary strategies that, when implemented together help promote sustainable transportation, reducing GHG emissions. Free or reduced fare transit programs incentivize transit use, thereby reducing car dependence and demand for parking.

Parking reform strategies, such as smart parking, curb management strategies, and other on- and off-street parking solutions for freight deliveries, rely on freight digitalization technology to reduce congestion and time lost to circling and idling.

Parking reform initiatives, such as adjusting parking regulations, implementing dynamic pricing, creating dedicated loading zones, or other curb management approaches can influence the availability of curb space for commercial vehicles during non-peak hours. By reallocating parking spaces or implementing flexible parking policies that prioritize loading and unloading activities during non-peak times, communities can create more opportunities for off-peak deliveries without causing congestion or disrupting traffic flow.

Ride sharing can reduce the demand for parking infrastructure, as carpools and vanpools replace the need for multiple single occupancy vehicle parking spaces. As such, ride sharing can help improve the acceptance and effectiveness of parking reform strategies.

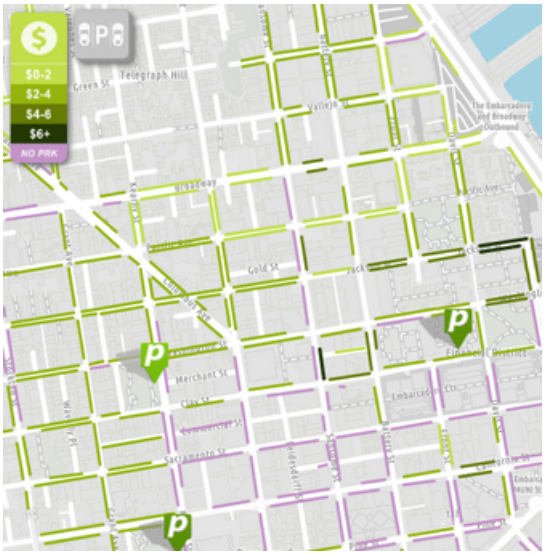
Parking requirements are often included within zoning codes. Zoning codes typically dictate how much parking must be provided for different types of developments, such as residential, commercial, or industrial. Coordinating parking reform with zoning reform can improve the efficiency of land designated for parking and encourage ease of access to walking, biking, and public transit.

View All Strategies

CASE STUDIES

SFPARK - DEMAND RESPONSIVE PARKING PRICING

The San Francisco Metropolitan Transit Agency (SFMTA) manages SFpark, a demand-responsive pricing program, to improve parking availability in metered spaces and City-owned parking garages. The program began as a pilot project in 2011-2013, which was supported by Federal funding through USDOT's Urban Partnership Program and was formally implemented in 2017. Results over the last decade show that SFpark has resulted in lower average parking rates, more accessible parking, and reduced VMT and GHG emissions.



San Francisco demand-responsive parking pricing (Source: SFMTA).

SEATTLE PERFORMANCE-BASED PARKING PRICING PROGRAM

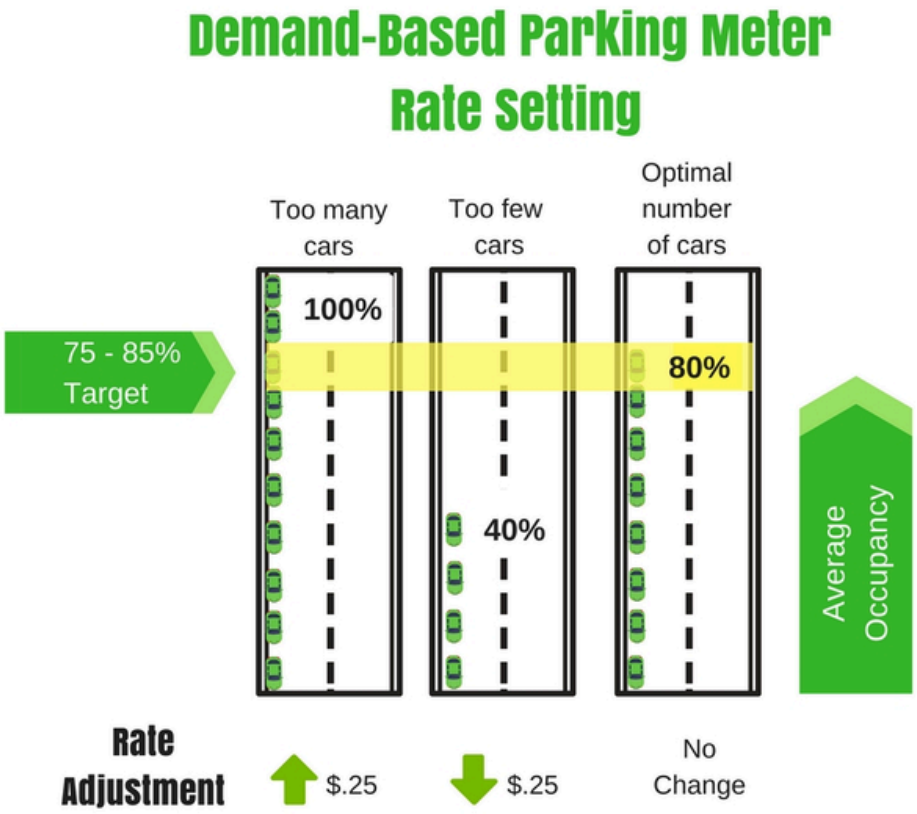
Since 2010, the Seattle Department of Transportation (SDOT) has managed a performance-based parking pricing program which adjusts rates, time limits, and paid hours of operation. To determine parking conditions, SDOT uses a model that predicts parking activity based on transaction data and adjusts pricing to achieve a target range of 70-85% on-street occupancy. The program has been shown to decrease GHG emissions and VMT (less circling = less congestion) and improve safety for pedestrians and cyclists (circling drivers = more distracted drivers).

NEW YORK CITY OPEN STREETS

New York City's Open Streets program focuses on creating public spaces by transforming streets into spaced for events, pedestrian and bike mobility, outdoor learning at schools, and more. The type of Open Street utilized dictates the vehicle use in the zone, either limiting access to emergency vehicles only in a full closure or designating use for pedestrians and cyclists but allowing limited local access at less than 5 miles per hour. As of Summer 2024, there are over 350 approved Open Street locations, with 41% located in underserved communities.

BALTIMORE DEMAND-BASED PARKING METER RATE SETTING

Beginning in the Summer of 2017, the Parking Authority of Baltimore City started using the demand for parking spaces to determine the hourly parking meter rate on blocks in Central Downtown, Mount Vernon, and 4 other areas. Meter rates are adjusted using data collected every 6 months with the goal of one or two available parking spaces per block, or a target of 75 to 85% occupancy. The program has provided benefits to businesses that rely on patrons being able to find a spot and reduced traffic congestion.



Baltimore demand-based parking meter rate setting
(Source: City of Baltimore Parking Authority).

IMPLEMENTING PARKING REFORMS: **WHAT TO READ NEXT**

The Institute for Transportation and Development Policy developed Ideas to Accelerate Parking Reform in the United States, which describes different parking reform strategies with supporting statistics, case studies, and interviews. Several additional resources are linked in the Resources section below.

PARKING BENEFIT DISTRICTS

In parking benefit districts, funds collected from parking are allocated towards specific community projects, such as improving the streetscape. The designated use of funds to better the community can improve the appeal of paying for parking to residents.

From 2006 to 2011, a pilot study turned portions of West Campus, Austin, Texas into a parking benefit district in which a portion of the revenue from parking was reinvested into the neighborhood. In the first year of operation, the PBD raised $163,000 of which $40,000 funded new bike lanes, crosswalks, transit shelters, and benches (Urban Transportation Commission, 2010). Read more about the City of Austin's Parking Benefit District here.

PUBLIC ENGAGEMENT

Engaging the public through outreach campaigns is an important step to identifying community needs and facilitating smooth implementation of parking forms.

The SFPark pilot study organizers distributed pamphlets that explained the program to downtown workers, hung posters in garages, ran an ad campaign, and conducted one-on-one meetings with community groups and political leaders (SFMTA, 2014). Read more about community involvement in parking benefit districts in the Key Groups section of this guidance document: Parking Reform Network, Parking Benefit Districts: A Guide for Activists.

Hartford, Connecticut eliminated parking minimums and instated parking maximums in the downtown area in 2016. After the changes attracted new development projects and public support, they were enacted city-wide a year later (Bronin, 2018).

RESOURCES

GENERAL RESOURCES

Parking Reform Network, Parking Mandates Map: This map highlights communities across the county that have implemented parking reforms with detailed information about each community and reform. There are options to filter results by scope and type of reform, land use, implementation stage, and population.

EPA, Steps for Implementing Parking Reforms in Urban and Suburban Zoning Codes (p. 16-20): This chapter of EPA's "Essential Smart Growth Fixes for Urban and Suburban Zoning Codes" explains different parking strategies and outlines an approach to implementation.

Oregon Department of Land Conservation and Development, Implementing Parking Reform Guide: The information in this step-by-step guide is useful in Oregon and beyond. It includes tips for planners and governments to construct a plan, consider language, and engage with the community to best implement parking reforms.

Institute for Transportation and Development Policy (ITDP), Breaking the Code: Off-Street Parking Reform Lessons Learned: This guide provides information on parking reform strategies with seven case studies from around the globe.

ITDP, Ideas to Accelerate Parking Reform in the United States: This guide details different parking reform strategies and makes an argument supporting their implementation with statistics, case studies, and interviews.

TOOLKITS AND MODELING APPROACHES

National level

CMAQ Toolkit: This kit offers a variety of tools to support CMAQ implementation, including a parking pricing tool that links changes in pricing and parking utilization rate to traffic demand management.

CNT Interactive Tools: This library offers parking tools that model parking utilization in areas such as Washington, D.C., King County, Washington, and Bay Area, California.

State level

GreenTRIP Connect: This is a free online tool that calculates how right-sized parking, smart location, affordable homes, and traffic reduction strategies can reduce costs and emissions.

WORKING WITH COMMUNITIES

Parking Reform Network, Parking Benefit Districts - A Guide for Activists: While this guide is geared towards activists, it provides useful case studies, a detailed action plan, and information about key community groups.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

PUBLIC TRANSIT EXPANSION

Investing in public transit infrastructure supports thriving communities and mobility equity by improving connections to essential services and directly reduces carbon emissions by providing cleaner, more efficient travel options.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural & Tribal

Boosting public transit ridership can directly reduce greenhouse gas (GHG) emissions by displacing trips made by single-occupancy vehicles. **Public transit expansion includes both system expansion, such as building an entirely new light rail or bus rapid transit line, or service expansion, such as increased frequency or extended service hours for an existing bus line.** Expanding transit services can provide more people with more opportunities to use transit to reach their destinations, and in turn reduce GHG emissions. Transit investments also indirectly reduce GHG emissions by enabling compact, mixed-use development that reduces distances traveled between destinations. These indirect effects of transit funding are more difficult to measure, but potentially just as impactful or even more so than direct effects in the long run.

Expanded transit service could have the largest impacts in areas where the current level of service does not meet public transportation demand, or in areas with large populations unserved or underserved by public transportation.

Funding for increased transit service would help to address public transportation gaps, particularly in underserved communities. New service in "transit deserts" (i.e. area with limited public transit supply) can most effectively serve users and reduce emissions by providing transit service that is appropriate to the community context, including new viable transit options in suburbs.

Extending Service Hours

Providing increased transit service at different times of day can encourage more people to use transit rather than driving alone. Transit trips typically fall into three types: commute, non-commute, and special event/visitor. Weekday, morning-to-early-evening service meets the needs of many commute trips, but may not adequately serve other trip types or off-peak commutes. To increase transit trips, transit agencies can pilot providing increased nighttime, weekend, and off-peak service. Expanding off-peak service (late-night and early-morning service) can promote transit usage for both non-commuter trips and service worker commuting trips that require later and earlier hours. Weekend service can support trips for special events, trips made by visitors, service worker commuting trips, and other non-commute trips.

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A 2016 study found that service frequency and travel time were the two most important factors to riders deciding between taking a trip on transit or on another mode (TransitCenter, 2016). Other important factors include:

- Cost
- Shelters at stops
- Real-time arrival information
- One-seat trips (no need to transfer)
- Payment options
- Available seating
- "First and last mile" to a transit stop (Distance, perception of safety, streetscape elements)
- Service reliability
- Amenities around a transit stop
- Accessibility and wayfinding

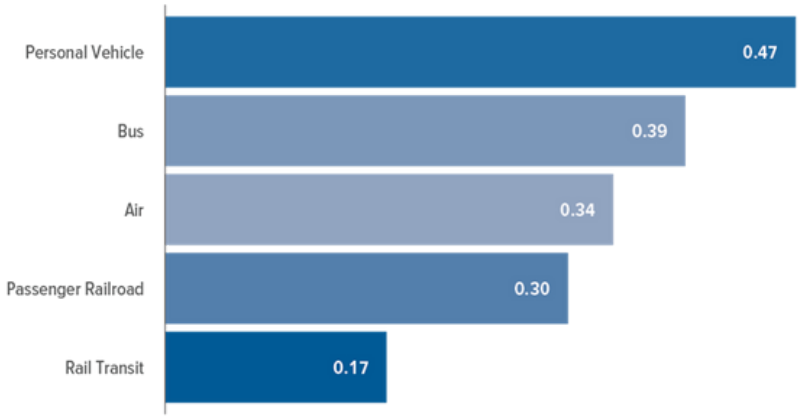
GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

PUBLIC TRANSPORTATION IS MORE ENERGY EFFICIENT THAN SINGLE OCCUPANCY VEHICLES

Passenger vehicles produce on average 0.47 lbs. of CO_2 per passenger-mile compared to 0.17 lbs. of CO_2 per passenger-mile emitted from rail transit and 0.39 lbs. of CO_2 per passenger-mile from buses (Congressional Budget Office, 2022).

Average Carbon Dioxide Emissions per Passenger-Mile, by Mode of Transportation, 2019
(Source: Congressional Budget Office, 2022)



Did you know?

Replacing a single driver's 10-mile daily commute with public transportation can save a household an estimated 4,627 pounds of carbon dioxide per year – an 8.1% reduction in the typical American household's annual carbon footprint (Federal Transit Administration, 2010).

A typical trip on public transit emits 55% fewer GHG emissions than driving alone (NASEM, 2021).

ANNUAL GHG AND VEHICLE MILES TRAVELED (VMT) REDUCTIONS

In 2018, the U.S. saved an estimated 63 million metric tons of CO_2 equivalent emissions through public transit and avoided 148 billion miles of personal vehicle travel, or 5% of the 3 trillion total U.S. vehicle miles that year (NASEM, 2021).

Analyzing these savings reveals the impact of public transit on both individual travel choices and broader land-use patterns. Passenger surveys indicate that approximately one-third of transit passenger miles would otherwise have been driven by car. This translates to a direct reduction in emissions and traffic congestion by encouraging a change in modes from cars to public transit.

However, an even larger portion of the savings, 88%, is attributed to the indirect effects of public transit on the built environment.

These indirect effects include encouraging shorter trips, reducing overall vehicle use, and supporting more walking and cycling trips due to compact, transit-oriented development patterns (NASEM, 2021).

BENEFITS FROM SPECIFIC STRATEGIES

Increased Services and Extending Network Coverage or Hours: A study by the California Air Pollution Control Officers Association (CAPCOA) estimates that increasing transit service could mitigate up to 11.3% of GHG emissions from vehicle travel in a community, and up to an additional 4.6% by extending transit network coverage or hours (CAPCOA, 2021).

Line extensions, increased service frequency, and increased speed: A study from Lawrence Berkeley National Laboratory modeled the effects of six specific transit projects in the San Francisco Bay area. The study found that these interventions would shift up to 10 percent of new transit riders from personal and ridehail vehicles, and improve mobility (travel distances, speeds, and times) for existing transit riders. These types of projects likely have larger benefits over the long run, when travelers can change their home or work location in response to improved transit service (Poliziani et al., 2024).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Communities designed with transit riders in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways. A 2014 study found "public transportation passengers have about one-tenth the fatality rate per mile as automobile passengers" (USDOT, 2015). Safer streets and connecting trails can, in turn, encourage further shifts towards active transportation. *See the active transportation strategy guide here.*

Passenger transportation by transit is significantly safer than transportation on highways. A FTA analysis found that the number of fatalities per vehicle mile traveled in personal automobiles is more than three times that of buses, and nearly twice that of heavy rail (U.S. Federal Transit Administration, 2023). Because transit vehicles have a much higher average occupancy than personal vehicles, the safety benefit of transit is even greater. In 2021, there were 197 fatalities reported on transit in the country, compared to nearly 42,939 highway deaths (BTS, 2021).

ECONOMIC GROWTH

Transit is a $79 billion industry and employs more than 370,000 people across more than 1,000 private companies and 4,000 transit operators. According to the American Public Transportation Association's research, every $1 invested in transit generates $5 in economic returns. Every $1 billion invested in public transportation supports and creates approximately 50,000 jobs (APTA, 2020).

RURAL COMMUNITIES

Expanding transit can provide a critical and safe transportation connection for rural residents with few other modes to choose from. Increased service can be particularly impactful for those who were previously located in a transit desert (Jiao and Dillivan, 2013).

A Minnesota study analyzing six rural and small urban transit agencies found substantial quantifiable benefits, including improved access to healthcare (estimated value of $228.5 million), increased low-cost

mobility options (estimated value of $7.6 million), reduced reliance on public assistance programs (estimated value of $19.1 million), and decreased dependence on others for rides (estimated value of $18.3 million) (Mattson, 2020).

ACCESSIBILITY AND EQUITY

Public transit increases access to job opportunities, education, and everyday destination for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities. An independent report published in 2017 found that 21% of users of public transit are low income, 49% do not have college degrees, 60% are people of color, and 46% do not have consistent access to a vehicle (APTA, 2017).

Public transportation is linked to decreased loneliness, increased access to family and friends, and greater levels of socialization enroute compared to driving alone (VTPI, 2024., Williams et al., n.d.).

Transit provides greater opportunities for lower mobility individuals, including people with physical disabilities and the elderly, to access healthcare and other important services.

RESILIENCE AND ADAPTATION

Public transit can help people deal with the impacts of natural disasters by supporting evacuation and emergency response activities. Public transit is one of the most widely used evacuation methods during emergencies. For example, the Baldwin Regional Area Transit System in Alabama ran special evacuation routes and microtransit service to provide communities with safe transportation during Hurricane Sally (Rosander, 2023).

Expanding public transit service to connect with or include mobility hubs also promotes community resilience during extreme weather events. Mobility hubs connect people with a range of transportation options, from public transit to shared micromobility and active transportation. Mobility hubs may be co-located with resilience hubs, facilities that provide essential services during and after weather crises (Rosander, 2023).

COST SAVINGS

Investments in public transit can reduce personal transportation costs by reducing the need for car maintenance, fuel, and parking costs. Those who stop owning a car and transition to using transit can save nearly $13,000 per year. These savings have increased in recent years due to rising new and used automobile prices and gas prices, while average monthly public transit fare prices have not increased (APTA, 2021).

In 2011, U.S. public transportation use saved 865 million hours in travel time (Texas A&M Transportation Institute, 2012). Those hours can be repurposed to additional workplace productivity or rest and recreation.

AIR QUALITY AND HEALTH

Reducing the number of emissions-emitting vehicles on the road through increased transit use (especially in densely populated areas) will decrease air pollutants that are harmful to human health (VTPI, 2024).

New or expanded public transit options can improve health outcomes by improving air quality, increasing physical activity, decreasing injuries from motor vehicle crashes, and improving mental health. Access to public transit can also reduce health disparities by increasing access to healthier food options, medical care, and other services (Health Affairs, 2021).

COST CONSIDERATIONS

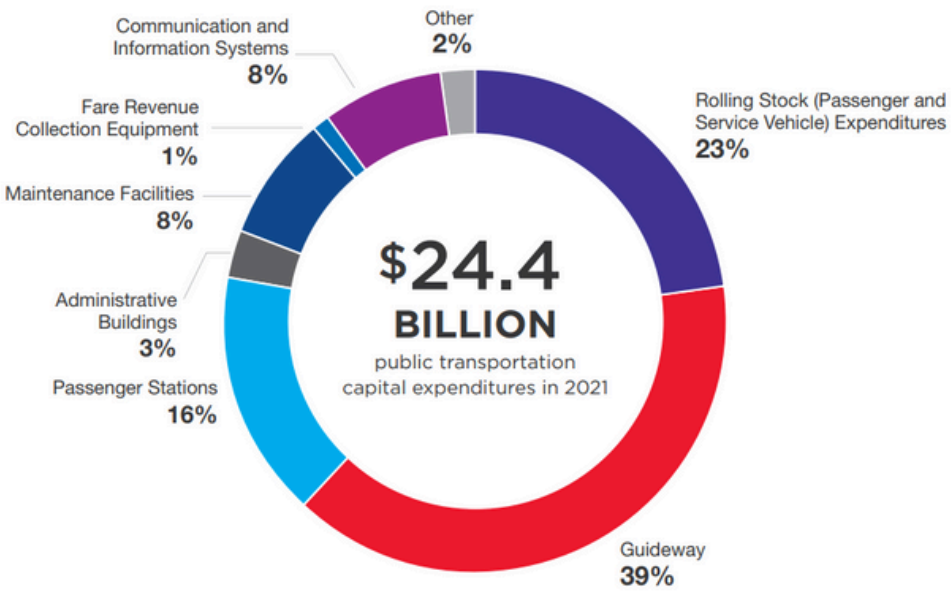
COST OF IMPLEMENTATION

The cost to expand public transit services can vary significantly based on what existing services are available and the scale of the expansion. Expansion could range from extending a bus line or providing service for additional hours, to building an entirely new light rail service or starting transit service in a previously unserved community.

Public transit capital improvements and operations are funded by passenger fares, public transit agency earnings, and financial assistance from different levels of government. The American Public Transportation Association (APTA) found that in 2021, capital expenditures totaled $24.4 billion in the U.S., with 39% of spending going towards guideway projects, 23% to rolling stock upgrades, and 16% to passenger station projects (APTA, 2023).

On a per vehicle mile basis, railway modes (commuter rail and light rail) are more expensive than roadway modes (bus, demand-responsive trips) due to the use of larger vehicles over shorter distances. In terms of cost per unliked passenger trip, heavy rail carries the lowest costs given its high capacity (APTA, 2023).

Public transit operating expenses (e.g., labor and fuel) are about two-thirds of all transit service expenses, while capital expenses (e.g., bus purchases) comprise about one-third (Mallet, 2024).



Total capital expenditures by type in the United States in 2021 (APTA, 2023).

Explore cost data for specific rail projects at Transit Costs Project. A few examples of cost per kilometer (in M$) for U.S. transit capital projects. Date of completion is given in parentheses.

- New York 7 Train Extension, 100% Tunnel (2014): $1,500
- Los Angeles Purple Line, Phase 1 (2024): $444
- Boston Green Line Extension (2022): $301
- San Franciso BART to San Jose, 83% Tunnel (2024): $1,270
- Miami Metrorail Extension (2012): $129

Bus rapid transit systems generally cost $5 million to $20 million per kilometer (ITDP, 2017).

An analysis by the ENO Center for Transportation (2020) found that light rail transit projects in the U.S. (excluding New York City outliers) averaged $107 million per kilometer, rising to $162 million when including New York City.

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FTA's Flexible Funding for Transit and Highway Improvements website for more detail.

FTA maintains a list of transit grants, here.

FTA's **Capital Investment Grants (CIG)** program funds transit capital investments including new and expanded rapid rail, commuter rail, light rail, streetcars, bus rapid transit, and ferries (49 U.S.C. § 5309). CIG makes transit more widely available, giving more Americans a low carbon transportation option.

FTA's **Public Transportation on Indian Reservations (Tribal Transit Program or TTP) Program** provides funding to Federally recognized tribes for capital, operating, planning, and administrative expenses associated with public transit projects. The TTP is a set-aside from the Formula Grants for Rural Areas program that includes a formula program and a competitive grant program.

FHWA's **Carbon Reduction Program** funds projects designed to reduce transportation CO_2 emissions form on-road highway sources, including public transportation projects eligible under 23 U.S.C. 142.

FTA's **Better Utilizing Investments to Leverage Development (BUILD) Transportation Grants Program** funds investments in transportation infrastructure, including transit.

FTA's **Buses and Bus Facilities Discretionary Grants** assist in the financing of buses and bus facilities capital projects, including replacing, rehabilitating, purchasing or leasing buses or related equipment, and rehabilitating, purchasing, constructing or leasing bus-related facilities.

FHWA's **Surface Transportation Block Grant (STBG) Program** provides flexible funding that may be used by States and localities for projects to preserve and improve the conditions and performance on any Federal-aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects.

FTA's **State of Good Repair Grants Program** provides capital assistance for maintenance, replacement, and rehabilitation projects of high-intensity fixed guideway and motorbus systems to help transit agencies maintain assets in a state of good repair in urbanized areas.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including many types of projects that improve public transit.

COMPLEMENTARY STRATEGIES

Like service expansion, free and reduced fare transit is an excellent strategy for increasing access to public transit, especially for low-income and fixed income riders. Free and reduced fares can also be used to encourage riding new systems, as exemplified in the North Carolina case study above.

Transit system integration involves connecting transit to other transportation modes to create seamless connections. Expanding transit can create additional or more frequent connections.

Public transit and transit-oriented development are mutually reinforcing strategies. TOD can increase the demand for public transit services by creating dense, mixed-use neighborhoods where residents have easy access to transit options. Public transit expansion can support TOD by providing reliable and convenient transportation access to and from these developments, thereby increasing their attractiveness and viability. Overall, combining TOD with public transit expansion can lead to lower GHG emissions, and more vibrant, livable communities.

Most transit trips start with a walking or biking trip segment, making safe connections between active transportation and transit infrastructure crucial. Transit is also key for extending active transportation trips beyond a bikeable or walkable range.

Bus rapid transit is a transit service type growing in popularity as a public transit expansion option, due to its ability to reduce travel times and increase capacity at a comparable level to light rail transit, while at a lower cost.

Zoning codes can have a significant impact on the expansion and effectiveness of public transit systems. By shaping land use patterns, densities, and development patterns, zoning can either facilitate or hinder the expansion of public transit infrastructure. Zoning codes that promote mixed-use developments, higher densities, and TOD can create supportive environments for public transit expansion.

Commuter benefits can serve as a support strategy to transit expansion by encouraging more people to use public transportation.

View All Strategies

CASE STUDIES

MBTA'S EARLY MORNING AND LATE-NIGHT BUS SERVICE PILOTS

Source: Massachusetts Bay Transportation Authority

The Massachusetts Bay Transportation Authority (MBTA) conducted two pilot programs in 2018 to provide late night and early morning bus service. In April 2018, MBTA started service before 5am, seven days a week, on Boston's busiest bus routes. In April 2019, early morning service was made permanent. Complementarily, in September 2018, MBTA expanded bus service from 10pm to 2 am with additional trips, later scheduling, and route variations to include areas where night service was most needed. In September 2019, some of these changes were made permanent.

RURAL NORTH CAROLINA'S TRANSIT EXPANSION

In 2018, Greenway Public Transportation, a transit provider for the Western Piedmont Regional Transit Authority in rural Conover, North Carolina, launched new flex service routes after securing grant funding. The routes aimed to serve low-income and underserved communities and featured a free promotional service period while riders learned about the new routes. Compared to the previous year, Greenway saw a ridership increase of almost 70% in 2019 and found the new service was especially useful for connecting riders to a health facility.

KING COUNTY METRO'S RAPID RIDE

The Seattle area's King County Metro transit agency currently operates seven bus rapid transit lines, with five additional lines planned. The use of semi-exclusive bus lanes, queue jumps, and off-board fare collection contribute to time savings of up to 20% over previous local bus routes. The system is not only faster but features increased frequency as well, attracting high ridership.

> Read more about Rapid Ride and bus rapid transit in the Bus Rapid Transit Strategy Guide.

Source: King County

UNALAKLEET TRANSIT PROGRAM

Administered by the FTA, the Tribal Transit Program provides critical funding to enhance public transportation in tribal communities across Indian Country. In 2023, the Native Village of Unalakleet in Alaska received $1.4 million to acquire equipment for the year-round maintenance of vital transit corridors leading to an assisted living facility. Situated on Norton Sound, 180 miles southeast of Nome, the village offers on-demand transit services that connect residents to important destinations, including the health clinic, grocery store, post office, tribal office, airport, and other essential services. In 2022, Jicarilla Apache Nation and the Pueblo of Santa Clara were both awarded $140,000 to upgrade two bus stops with shelters and passenger amenities, significantly improving accessibility for tribal residents. These enhancements will create a safer and more comfortable waiting environment, facilitating reliable transit service.

IMPLEMENTING PUBLIC TRANSIT EXPANSION: **WHAT TO READ NEXT**

The Federal Transit Administration website contains information and resources related to public transportation planning and funding. FTA's Planning Resource Library webpage is a good place to start for guidance on many transit related planning topics.

When planning for public transit expansion, it is important to involve the community to ensure the transit services meet their needs. The Transit Planning 4 All Inclusive Planning Guide details how to improve inclusivity in transportation planning efforts.

The American Public Transportation Association (APTA) publishes an annual Public Transportation Fact Book, containing data across all aspects of transit across the U.S. and Canada.

Source: New York Transit Museum

New York City MTA's new R211 subway trains improve accessibility and wayfinding in public transit. New features enhance travel experience through improved signage and audio announcements that ease navigation.

Additional design elements include dedicated seating for passengers with disabilities, larger and clearer digital displays, and improved lighting, all of which contribute to a safer and more intuitive travel experience. These enhancements ensure that everyone can navigate the subway system with confidence and ease.

For more information, visit MTA's site.

Expanding Public Transit with Bus Priority Lanes: Investing in bus priority lanes is a strategic approach to enhance public transit infrastructure and promote mobility equity. While a single lane of private vehicles on a city street might handle 600 to 1,600 people per hour, a dedicated bus lane can move a staggering 8,000 passengers in the same timeframe (NACTO, 2016).

Key Considerations for Bus Lane Implementation include:

Context-Specific Treatments

It is essential to tailor bus lane designs to fit the unique needs of each corridor. This may include accommodating commercial deliveries or ensuring that stopped buses can be passed by other buses to maintain efficient service. Agencies must also determine whether bus lanes will operate 24 hours a day or only during peak hours.

Maximizing Efficiency

Integrating features such as transit signal priority and off-board fare payment can significantly enhance the efficiency and reliability of bus services. Additionally, managing right-hand turns at intersections is critical, as these can disrupt bus flow.

For more information, visit NACTO's Urban Street Design Guide.

RESOURCES

GENERAL RESOURCES

American Public Transportation Association Recommended Practice: This resource provides information to transit agencies looking to quantify both GHG emissions generated and reduced by transit.

Transportation Research Board Public Transit as a Climate Solution Webinar: This webinar explores how to incorporate public transit as a climate solution featuring research from "TCRP Report 226: An Update on Public Transportation's Impacts on Greenhouse Gas Emissions."

- *A spreadsheet tool developed in conjunction with the report that allows the user to apply future scenarios to see how their transit agency's GHG impacts change with electrification, clean power, and ridership.*

National Aging and Disability Transportation Center (NADTC): This center provides technical assistance, training, and other resources on accessible transportation to empower older communities, people with disabilities, and their caregivers.

TOOLKITS AND MODELLING APPROACHES

FTA Transit Greenhouse Gas Emissions Estimator: This is a spreadsheet tool allowing users to estimate the GHG emissions generated from the construction, operations, and maintenance of public transit systems.

The California Air Pollution Control Officers Association Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: This handbook provides GHG reduction formulas for expanding transit network coverage or hours or increasing service frequency.

FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Emissions Calculator – The toolkit provides a number of modules that can help estimate the emissions reductions associated with transit improvements including service improvements and bus and system expansion.

WORKING WITH COMMUNITIES

Transportation Research Board Transit Cooperative Research Program's (TCRP) Inclusive Public Participation in Transit Decision-Making: This is a published resource featuring effective public participation methods for engaging communities of color, people with limited English-language proficiency, low-income populations, and people with disabilities.

American Cities Climate Challenge Transit Priority Toolkit: This toolkit gives cities an easy-to-use resource to engage with internal staff, stakeholders, decision makers, and the public about transit priority projects.

RURAL SPECIFIC

National Rural Transit Assistance Program (RTAP) Resource Library: This resource has a collection of resources and training materials specific to rural and Tribal transit systems, including the TRB TCRP's workbook "Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation."

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

RIDESHARING AND CARSHARING

Ridesharing and carsharing promote shared transportation, reducing traffic congestion, parking infrastructure demand, and fuel consumption, while providing cost-effective, convenient travel options.

Also known as
CARPOOL AND VANPOOL

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OVERVIEW

Best Suited for:

Long Term & Short Term
Urban, Suburban, Rural, and Tribal

A rideshare is a trip take by two or more people sharing one vehicle to a common destination. Carpooling involves the use of a personal vehicle to transport two or more people within a neighborhood, often with a shared responsibility of driving and transportation expenses.

Vanpooling is a similar practice involving a van instead of a car, with the potential to carry a larger number of passengers at a time (up to 15). Vanpools can be driver-owned or sponsored by a public agency or third party to assist with commutes to a workplace or other shared destination. **Vanpools are most effective as an emissions reduction strategy when passengers live and work within proximity to each other** such that one vanpool trip takes fewer overall vehicle miles travelled per passenger than several single occupancy car trips.

Ridesharing can be facilitated through informal, formal, and ride matching services. Informally, drivers can wait at designated pick-up sites such as park-and-ride lots or busy transit locations and drop off passengers in designated locations such as central business districts.

Did you know?

Vanpools emit about 105 grams of carbon dioxide (CO_2) per passenger-mile, compared with 406 grams CO_2 per mile by single-occupancy passenger cars (TTI, 2023)

Formal options can include agency/organization-scheduled ride sharing, often through a third-party provider for commuting employees. Ride matching services can help passengers find ride sharing options through committed vanpool groups or dynamic ride sharing programs that offer real-time sharing arrangements through GPS and wireless networks.

Carsharing programs are often operated by private companies or other organizations to rent out cars for short time periods, without the costs or burden of vehicle ownership. These companies or organizations often have their own vehicle fleets and are located in neighborhood lots, public transit stations, employment centers, and universities.

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Carsharing is also available through peer-to-peer systems, which allow individuals to rent their personal vehicles through companies that broker the transactions by providing online platforms, safety certifications, auto insurance, or other services. Several cities provide dedicated parking space incentives to encourage carsharing. These programs can reduce demand for parking reliance on individual vehicle ownership, and household transportation costs associated with vehicle ownership, enabling more car-light and car-free households.

Park and ride facilities can be used as carpool and vanpool commuter meeting spaces. The lots provide parking spaces for commuters in urban, suburban, or rural areas to park individual cars and continue onto longer commutes through carpools, vanpools, or buses. Park and ride systems contribute to decarbonization because they provide a convenient opportunity for commuters to use a less carbon-intensive travel mode, such as public transportation, carpool, or vanpool, for a portion of their commute. These systems can also incorporate cool pavements, tree canopy, or solar photovoltaic shade canopies to reduce the urban heat island effect as well as evaporative emissions from parked vehicles. Park and ride facilities can also host dedicated electric vehicle parking spots and/or charging infrastructure. See the Electric Vehicle Charging Infrastructure strategy page.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

CARSHARING ENCOURAGES MODE CHOICE AND LESS CAR USE

Carsharing programs are often successful because they program consumers with better or sufficient mobility at a reduced cost and drive a reduction in private vehicle use.

Several North American studies show a reduction in VMT/vehicle kilometers traveled (VKT) per person due to carsharing, with some estimates reaching more than 60% reduced travel (Shaheen et al., 2016).

Research shows the correlations between carsharing and walking, cycling, and transit use. National and local studies in North America show carsharing participants walk more often, ranging from 12% to 54% more than other commuters. Carsharing participants (13.5% to 54%) also take public transit more frequently (Shaheen et al., 2016).

GHG EMISSION BENEFITS OF CARSHARING

A 2010 study found while carsharing in North America shows some increase in GHG emissions for carless households, the cumulative effect is a decrease in GHG emissions, especially as urban households use carsharing as part of a car-free or car-light lifestyle. The study results estimate aggregate carsharing GHG reduction of 158,000 to 224,000 metric tons per year (Martin and Shaheen, 2011).

A more recent study in 2020 estimated GHG emissions reduction associated with carsharing is likely close to the range of 3% to 18%, with inclusion of long term and end of life factors such as modal shift and shared vehicle lifetime affect included in the calculation. The study is based on case study data from Calgary, Canada, San Francisco, USA, and The Netherlands (Amatuni et al., 2020).

GHG EMISSION BENEFITS OF RIDESHARING

Vanpools can be used for long-distance commutes of 20 to 100 miles each way and typically carry between 7 and 15 people. The associated reduction in GHG emissions, particularly on a per passenger mile basis, can be 70 vehicle-miles of emissions daily, according to some studies (Ridesharing Institute, 2022).

Different studies have modeled scenarios where all demand for car travel must be met by ridesharing. In one study in Munich, Germany, 2% of cars could meet all demand in the city, decreasing the number of vehicle kilometers by 54%. Another study in Lisbon, Portugal found a VKT decrease of 25% if all motorized trips are undertaken by a fleet of shared vehicles (Zwick et al., 2021; Martinez and Viegas, 2017).

Employee-sponsored vanpooling has the potential to reduce up to 20.4% of GHG emissions compared to an individual employee commute (CAPCOA, 2021).

VMT, PARKING, AND CONGESTION BENEFITS OF RIDESHARING

Local impact: A study in Minneapolis and St Paul, MN found that transit and carpooling incentives reduced vehicle trips by 27-37% and reduced parking demand by 11-21% across 6 employment sites (TTI, 2024a).

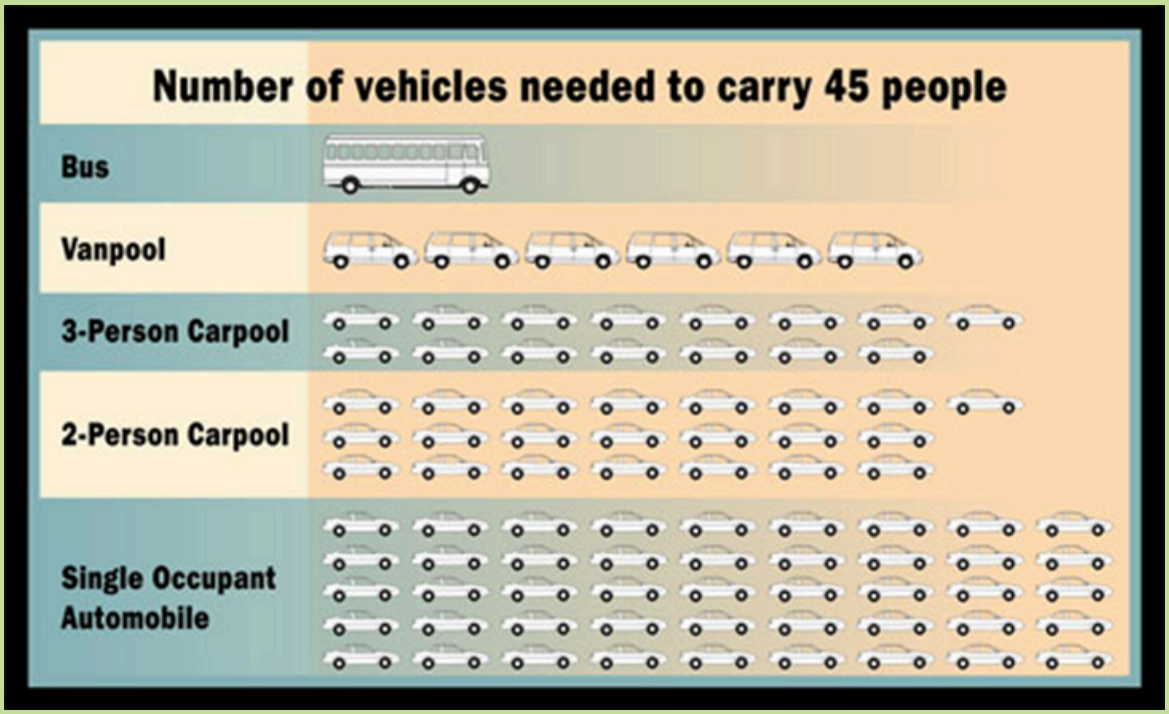
National impact: A 2016 study on the impacts of ride sharing on vehicle miles traveled in the United States noted the combination of a moderately used regional dynamic ride sharing system, along with a 10-30% increase per mile cost of vehicle travel, can reduce 11-19% of VMT across the country (Rodier et al., 2016).

Employer vanpool: A 2010 study notes the VMT reduction potential of employee-based vanpooling to be 4-6% for each employee participating in vanpool program compared to employees who do not participate (Boarnet et al., 2010).

Employer ridesharing program: Bellevue City Hall in Washington introduced a ride sharing program to its employees with discounted carpool parking and subsidized vanpooling. The ride sharing program decreased vehicle ridership by 30% across 650 employees (TTI, 2024b).

Many large employers choose to implement travel demand management programs featuring carpool/vanpool and ride matching incentives and services as key strategies to increase their Average Vehicle Ridership scores (Texas A&M Transportation Institute, 2024a). Average Vehicle Ridership scores improve if there are more people than vehicles traveling to the work site (South Coast AQMD, n.d.).

Comparison of 45 single occupant vehicles to carpool, vanpool, and bus alternatives.



Source: FHWA, 2016

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Carpooling can reduce the number of vehicles on the road, reducing congestion and improving safety for all road users (Shaheen et al., 2018). Large scale ride pooling has been modeled in New York City, with researchers finding 95% of car demand would be covered by 2,000 10-person vehicles, compared to the nearly 14,000 taxis that currently operate in the city. The same study also showed that 3,000 four-passenger cars could serve 98% of taxi demand (Alonso-Mora et al., 2017).

Carpooling also contributes to roadway safety by potentially providing multiple possible drivers in each car, reducing the risks associated with single-occupancy vehicles and long-distance driving, such as fatigue and accidents (Koester LLC, n.d.).

ECONOMIC GROWTH

Vanpool participants may be eligible for additional commuter benefits from employers. Vanpool participants may also be eligible for city, State and Federal benefits.

For example, Bellevue City Hall in Washington State provides its employees with a ridesharing program, including discounted carpool parking and subsidized vanpooling (TTI, 2024). See the Commuter Benefits page for more details.

Employers in Georgia can gain an annual tax credit for each employee that uses a Federal qualified transportation benefit at least 10 times per month. Under Georgia Code 48-7-29.3, employers must pay the Georgia corporate income tax and provide subsides for public transit or vanpooling to employees near the workplace to be eligible. Carpool or vanpool parking subsidies also count (Shaheen et al., 2018).

Commuter highway vehicles, such as vanpools, can provide up to $315 per month as a tax deduction for commuting expenses if criteria are met (Best Workplaces for Commuters, 2024).

Government employees of the City of Seattle and King County, WA receive a

100% subsidy for vanpooling (Seattle DOT, 2022).

LA Metro's ExpressLanes (dynamically priced toll lanes) offer toll-free travel and rewards to carpoolers through a Carpool Loyalty Program. Rewards for the Loyalty Program include a monthly chance to earn toll credits (Metro, n.d.).

ACCESSIBILITY AND EQUITY

Ridesharing options increase access for those who cannot or do not drive, especially the elderly, people with disabilities, and lower-income communities. For seniors, transportation is the most common reason for not leaving the home, limiting access to basic services. In contrast, both active and public transportation are linked to decreased loneliness, increased access to family and friends, and greater levels of socialization enroute as compared to driving alone (Williams et al., 2021; Litman, 2024).

Transportation costs are lower for ride share passengers. Low-income drivers may be able to offset their own transportation costs by carpooling or vanpooling.

> Massachusetts provides carpool, taxi, and ridehailing services and resources available in the State for older adults, people with disabilities, veterans, low-income commuters, and others without access to a car. This range of resources provides ways to bridge gaps in the transportation system (Commonwealth of Massachusetts, 2024).

Equity can be improved if access is available for non-English speakers. A study in Los Angeles, CA indicates the Latino population has double the rate of carpooling as a primary mode of transportation compared to other groups (Handy et al., 2009).

Ridesharing can eliminate gaps in transportation networks, such as facilitating first and last mile public transport access (FHWA, 2016). Carsharing can be an alternative for vehicle ownership, especially in areas lacking other transportation options.

AIR QUALITY AND HEALTH

Carsharing and ridesharing can reduce the number of emitting vehicles on the road (especially in densely populated areas), decreasing air pollutants that are harmful to human health (Litman, 2024).

Carpooling, in the long run, can reduce adverse air pollution impacts from reduced vehicle use, including for low income, minority, and environmental justice populations. (Shaheen et al., 2018).

Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways (EPA, 2014).

Ride sharing can reduce the burden of commuter stress for drivers and passengers (TTI, 2024a). A study based in California found that commuting stress levels were lower for vanpoolers compared to single occupancy vehicle commuters (Ditmore and Deming, 2018).

RURAL COMMUNITIES

Carpooling and vanpooling can increase access to destinations in rural areas where there are gaps in public transit, walking, and biking routes. This is particularly important for people with disabilities, low-income households for whom car ownership and use is prohibitively expensive, elderly people, and children commuting to school, activities, and social services (Shaheen et al., 2016).

Vanpooling is often used by rural residents to reach worksites located a long distance from their homes (Rural Health Information Hub, 2019). By using vanpools, commuters in rural areas can cut down on high commuting costs. This is particularly important for agricultural workers who are often low income and have long trips between their homes and work destinations. In California, the non-profit Miocar provides electric vehicle vanpooling to low-income rural communities at low costs (Descant, 2024).

The Clean Rural Shared Electric Mobility (CRuSE) Project is a U.S. Department of Energy funded project providing electric vehicle carsharing opportunities to rural and low-income communities, with five stations in the town of Hood River, Oregon. The carsharing services are provided by a private company, offering Spanish language options on its software app, alternate payment options, and tiered pricing to be accessible for low income users.

RESILIENCE AND ADAPTATION

Rideshare can offer a mode of transportation in disaster emergency situations, especially for populations in areas without access to other means of transport or for populations who are unable to use or afford other options (Borowski and Stathopoulos, 2020).

COST SAVINGS

Carpoolers can save on costs of fuel, roadway tolls, and congestion pricing, as total costs can be divided by the number of vehicle occupants. Time savings from the use of carpool lanes is an added benefit (TTI, 2024). METRO HOV lanes in Houston, TX saved the average commuter 12-22 minutes per trip (USDOT, 2015b).

Carsharing can decrease household transportation costs by reducing the cost of owning a personal vehicle and the associated costs of ownership, including auto insurance and parking. An estimate of carsharing savings in the U.S. is approximately $154 to $435 per year, depending on location and carsharing business model variations (Shaheen et al., 2016). Carpooling can save commuters vehicle wear and tear costs in the long run (FHWA, 2016).

The American Automobile Association estimates that a double occupancy vehicle commuting 25 miles each way per day saves around 50% more on transportation and vehicle maintenance costs per year (Harford County, 2024).

Employee sponsored vanpooling can provide cost savings for public agencies and employers. Passengers can also benefit from carpooling and vanpooling through reduced parking costs. A best practice for employers is to subsidize the cost of vanpooling for employees in close proximity to each other and provide vanpool priority parking (CAPCOA, 2021).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The cost to establish a ride sharing program is limited. Ride sharing impacts and is affected by related strategies such as the construction of high occupancy vehicle lanes and parking infrastructure, as well as individual public and private ride sharing programs operated.

Administrative costs for operating a commuter trip reduction program, such as an employer carpool, typically average $1 to $8 per employee-month. These costs cover program planning, marking, management, and performance evaluation (Litman, 2012).

The reduced need for parking spaces due to increased ride sharing can **save parking capital investment costs by $15,000 to $45,000** per space.

Additional operational **costs can be reduced by $360 to $2,000** per space. (EPA, 2005; Shaheen et al., 2018; Shoup, 2011)

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

FUNDING OPPORTUNITIES

FHWA's **Congestion Relief Program**, established under BIL, provides competitive grant funding for programs that reduce congestion through pricing roadway use and parking, among other methods of decreasing congestion. This would have the benefit of encouraging other modes of travel that take up less road space, such as ride sharing, while recapturing some of the value associated with road maintenance and construction from those who use the roads most.

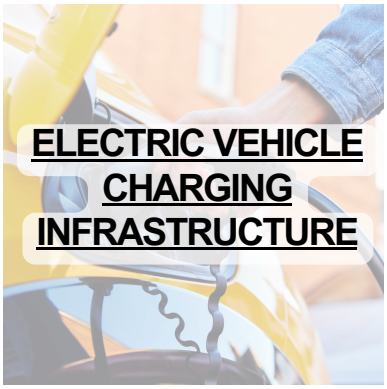
FHWA's **Carbon Reduction Program** (CRP) is an initiative providing funding to support travel demand management strategies across the country in an effort to reduce transportation emissions.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief.

The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including carpool/vanpool programs.

COMPLEMENTARY STRATEGIES

Ridesharing and carsharing reduce the demand for parking infrastructure. Carpools, vanpools, and shared cars replace the need for multiple single occupancy vehicle parking spaces. As such, ride sharing and car sharing can help improve the acceptance and effectiveness of parking reform strategies.



Charging infrastructure at park and ride locations can enable EV owners to drive to a meet-up point a short distance from home and charge their vehicle while using a single vehicle with more than one rider for the longer, shared trip segment.

High Occupancy Vehicle lanes and other road pricing formulas can incentivize car share and van pool, reduce costs for rideshare participants, and decrease time to destinations.

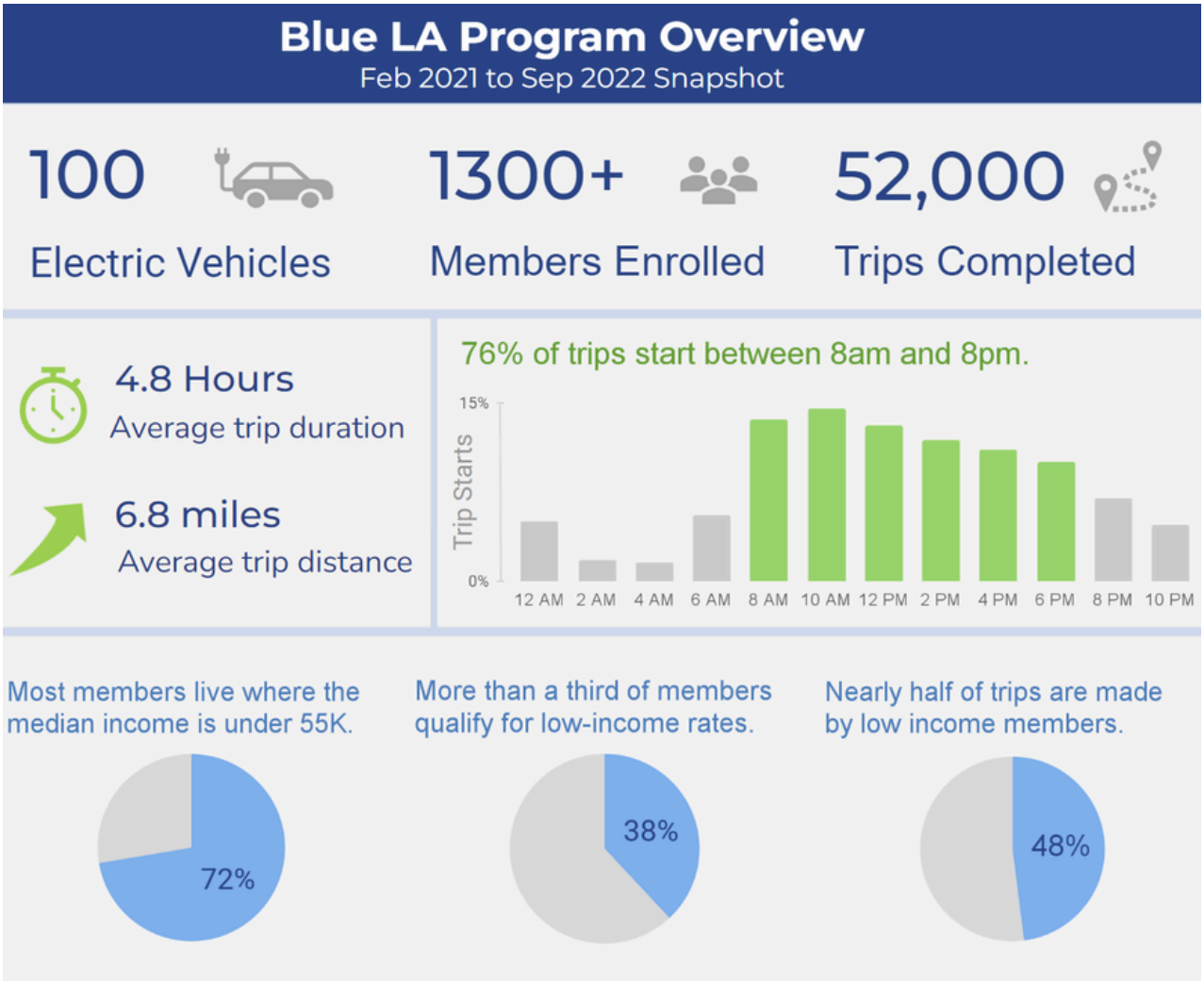
Commuter benefits can incentivize carpooling and vanpooling as viable alternative modes of transportation, benefiting both employees and employers by reducing commuting expenses while reducing GHG emissions.

View All Strategies

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

CASE STUDIES

BLUE LA ELECTRIC VEHICLE CARSHARING PILOT, CALIFORNIA:



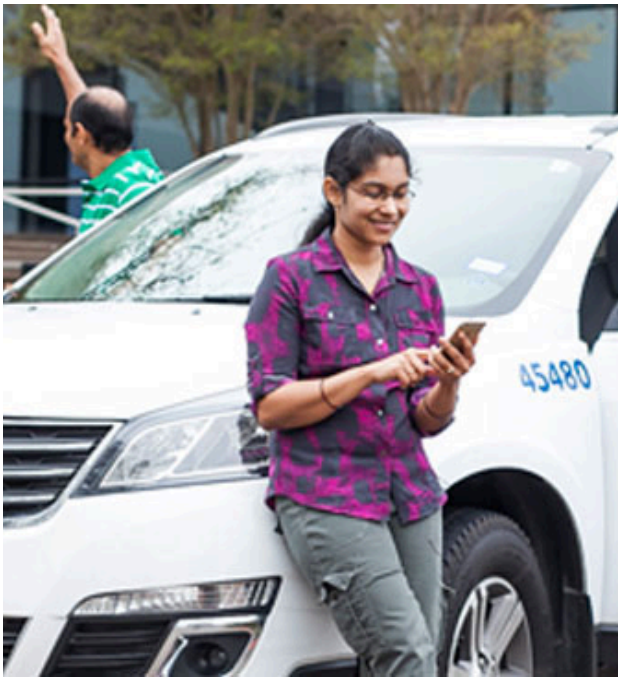
Source: BlueLA

In 2018, BlueLA piloted an electric vehicle carsharing option in Los Angeles, CA, with the aim to provide transportation options to disadvantaged communities and contribute to reducing GHG emissions in the car-centric city. The program deployed 100 shared battery electric vehicles and engaged community members to use the carsharing services as long term alternative to private vehicle use. BlueLA aims to reduce 2,150 tons of GHG annually. Initial outcomes from the first 10 months since the launch of the program have reduced an estimated 260 metric tons. The program is in line with State efforts to reduce GHG emissions by 40% by 2030. One of the key contributors to the success of the program is the one-way carsharing model, which reduces negative environmental impacts, such as air pollution, by not having to return the vehicle to the station of origin.

MBTA RIDE FLEX, MASSACHUSETTS:

RIDE Flex is a flexible, on-demand travel option for eligible RIDE customers. RIDE is the Massachusetts Bay Transportation Authority's (MBTA) paratransit service for people who are unable to use the subway, bus, or trolley all or some of the time due to temporary or permanent disability. Flex customers can schedule trips at any time directly through Uber and Lyft or through the RIDE Access Center (TRAC). To keep the Flex program affordable and sustainable, customers have a cap on how many subsidized trips they are allocated each month. The RIDE Flex service area includes the City of Boston, Logan airport, and surrounding suburbs, as well as transfers to transit agencies that service the western and southeastern parts of the state.

Source: MBTA



Source: CapMetro

CAPMETRO RIDESHARE, TEXAS:

In Austin, TX, the Capital Metropolitan Transportation Agency's (CapMetro) rideshare program provides eligible groups of 4 to 12 riders with a month-to-month vanpool lease agreement, including insurance, maintenance, 24-hour roadside assistance, and an optional fleet card for fuel that is billed monthly. The program is sponsored by CapMetro and operated by a private company. Vanpool fares vary based on vehicle type, commute distance, group size, fuel prices, and tolls. The monthly cost is shared by the number of riders and the rideshare program provides groups with a monthly subsidy toward the monthly vanpool lease.

MASON TRANSIT AUTHORITY, WASHINGTON:

The Mason Transit Authority (MTA) is an example of a rural vanpooling program offered to residents of Mason County, WA. The transit authority provides a van to transport rural residents with volunteer drivers and fares based on factors such as mileage and number of riders. The MTA also provides resources for rural residents to establish or join vanpools and use for ride matching.

Source: Mason Transit Authority

CALVANS, CALIFORNIA

CalVans is a vanpool service sponsored by a public transit agency, the California Vanpool Authority. The service provides vans to government employees, students, and agriculture commuters in rural areas who can drive themselves and/or others to work or school destinations. The program pays for fuel and maintenance, with only the fee of the commute required for users. A key feature of the program is the pilot project, Agricultural Industries Transportation Services. This service offers safe, reliable, and affordable transportation options for agricultural workers in rural areas to safely reach their workplaces. In October 2023, CalVans acquired electric passenger vans in an effort to support clean transportation as well as provide disadvantaged communities with transportation options to workplaces.

Caltrans agriculture vanpool porgram (Source: CalVans)

IMPLEMENTING RIDESHARING AND CARSHARING: **WHAT TO READ NEXT**

The U.S. DOT **Ridesharing Options Analysis and Practitioner's Toolkit** provides an overview of current ridesharing trends. It serves as a toolkit for public agencies to create ridesharing programs tailored to meet the needs of their constituency. The report also includes an index of public and private entities engaged in ride sharing.

Carpool Incentive Programs: Implementing Commuter Benefits as one of the Nation's Best Workplaces for Commuters explains the how-to details and benefits of establishing a carpool incentive program from the perspective of an employer.

The **Ridesharing Institute** site provides archival information on the institute's applied research, webinar series, and links to other research and resources.

Ride Together offers a **First Time Carpooler Guide** to join a carpool in Pierce County, WA. Although the resource provides county-specific information, the information can be applied to other contexts to understand the step-by-step process of carpooling.

Ride Together also provides a range of **resources** for carpooling, including best practices for participating in a carpooling group. The resources can be used as an example for other counties or jurisdictions to build similar guidelines for local carpools.

RESOURCES

GENERAL RESOURCES

GSA directive: This directive encourages agencies to reduce GHG emissions from official travel, including ride sharing with fellow employees with large transportation network companies (TNC), taxis, or shared shuttle services to destinations such as airports, hotels, conference venues, or meetings.

TOOLKITS AND MODELLING APPROACHES

National Level

FTA Transit Greenhouse Gas Emissions Estimator: The estimator is a spreadsheet-based tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operation, and maintenance phases of a project across select transit modes. Users input general information about a project, and the Estimator calculates annual GHG emissions generated in each phase. Includes vanpool.

FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ) Carpooling and Vanpooling Emission Reduction Calculator: This tool calculates emission reductions from projects that start carpool and vanpool programs, increase ridership in existing programs, or purchase vehicles for vanpool programs.

U.S. EPA Sample Calculation of Emission Reductions and Fuel Savings from a Carpool Program - Emission Facts: This document provides sample calculations to estimate GHG emissions reductions in total VMT for new or expanded carpool or ride share programs.

Shared-Use Mobility Center Shared Mobility Benefits Calculator: The calculator allows cities to estimate emissions benefits through the implementation of a range of shared mobility options, including carpooling, vanpooling, and carshare electrification. The tool offers a setting for the number of shared mobility options required to reach a desired emissions reduction goal.

Forth Mobility Carsharing Toolkit: Forth Mobility provides a toolkit based on its experience in launching a carsharing program, funded by the U.S. Department of Energy, in a rural town in Oregon. The toolkit includes considerations for developing a framework for launching a carsharing program, technology and vehicles, and operations, marketing, and evaluation.

State Level

The California Handbook for Analyzing GHG Emissions Reductions: This resource provides calculation methods on project site level GHG emissions and fuel reduction for employee-sponsored vanpooling.

Massachusetts CO_2 Emissions Reduction Calculator: This excel spreadsheet is a calculator that provides calculations of emissions reduction and fuel savings from a carpool program.

California Sustainable Transportation Household Carbon Footprint Calculator: This tool can be used at the household or individual level to calculate greenhouse gas emissions from walking, biking, carpooling, transit, and electric vehicles.

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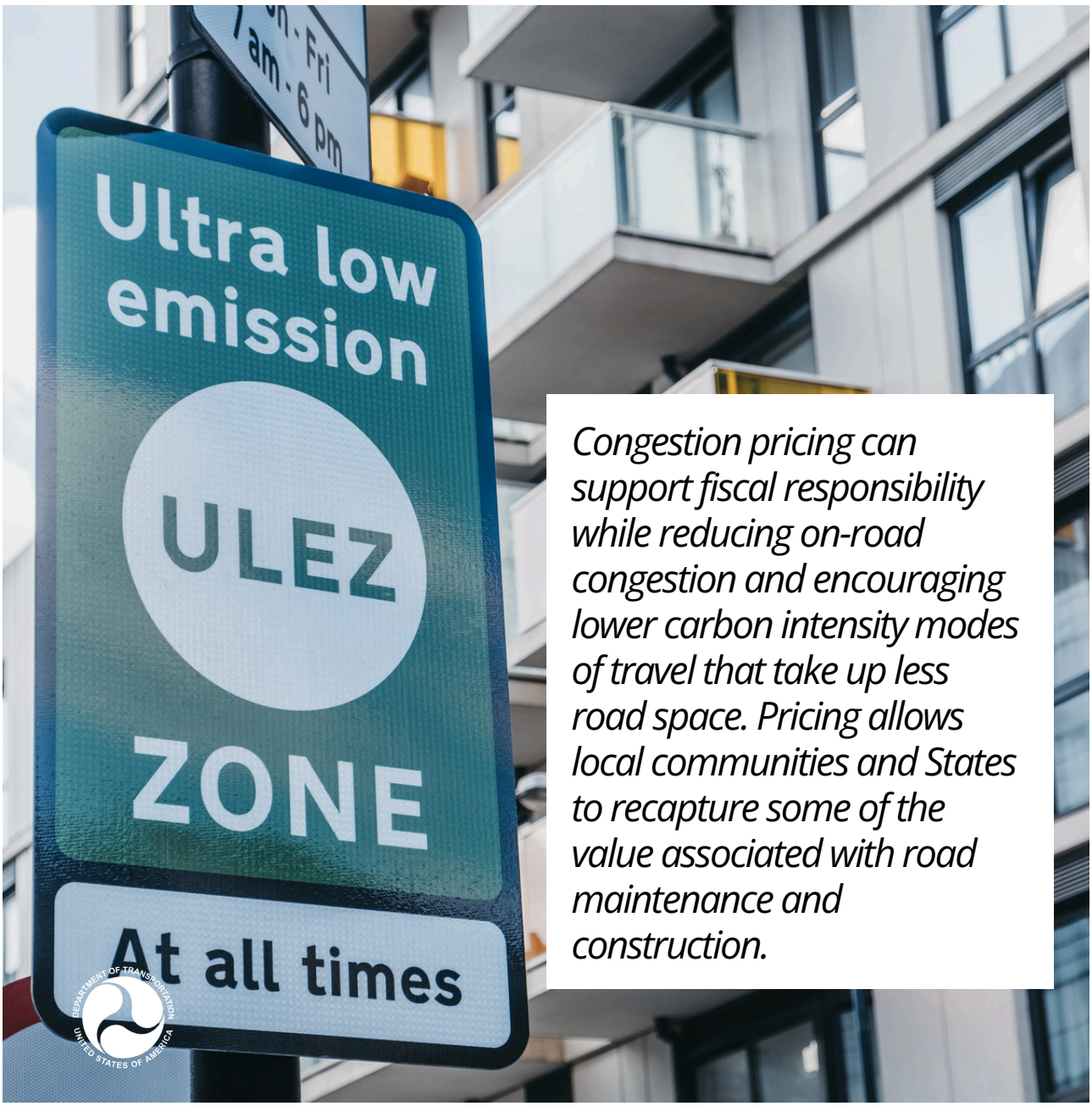
For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

ROAD PRICING



Congestion pricing can support fiscal responsibility while reducing on-road congestion and encouraging lower carbon intensity modes of travel that take up less road space. Pricing allows local communities and States to recapture some of the value associated with road maintenance and construction.

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OVERVIEW

Best Suited for:
Short term, pilot and educational campaign followed by full roll out
Urban

Traffic congestion can mean increased travel times, higher incident rates due to stop-and-go conditions, poor air quality, and impacts to trucking and higher cost of goods. **Road pricing programs involve charging drivers a toll to drive on busy roads to alleviate traffic congestion and reduce air pollution and greenhouse gas emissions from vehicles.** Tolls may be levied as flat fees to use a particular corridor or a specific zone or can be charged by vehicle mile traveled (VMT). VMT-based fees are also referred to as road usage charges (RUCs). There are four main types of road pricing strategies: variably priced lanes (e.g., express toll lanes), variable tolls on entire roadways, cordon charges for driving within or entering a congested urban area, and area-wide charges (per-mile fees on all roads within an area). Pricing programs may also be applied at ports to reduce freight-related congestion at terminals and connecting roadways.

Under most pricing programs, tolls typically vary by time of day and are collected electronically at regular roadway speeds. Revenues can be used to reduce the burden of pricing on low-income individuals and communities by for example, supporting toll discounts and subsidizing public transit passes.

Did you know?

In a 2015-2017 road usage charges pilot in California, 73% of participants felt that a road charge was a more equitable approach compared to the gas tax (CalSTA, 2017).

Pricing programs can also offset infrastructure costs by investing profits in local public transit, road maintenance, and active transportation projects. Generally, road pricing strategies work best when combined with other programs, including low and no-emission zones, off-peak delivery support, and transit-oriented development.

Congestion pricing, sometimes called value pricing, is one type of pricing strategy that helps to shift peak-period travel to off-peak times and other transportation modes. **Removing a fraction (potentially as small as 5%) of vehicles from a congested area can lead to significant travel efficiency improvements.** Congestion pricing can also reduce vehicle idling and associated emissions and provide an alternative to highway capacity expansions. See the Convenient Transportation: An Action Plan for Energy and Emissions Innovation, a joint report by USDOT, the Department of Energy, Environmental Protection Agency, and Department of Housing and Urban Development, for more information about road pricing and other fiscally-responsible transportation investments.

As vehicle fleets become more fuel efficient and electrified, State and local governments are likely to see decreasing revenues from gas taxes. Road usage charges (RUCs) are one alternative funding mechanism to support road maintenance and repair.

To date, 14 states and regional pilots have received federal funding to explore alternative funding sources, including RUCs.

- California
- Eastern Transportation Coalition: A partnership of 17 states and DC
- Hawaii
- Minnesota
- Missouri
- New Hampshire
- Oregon
- RUC America: A consortium of 19 state transportation departments
- Utah
- Washington

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

ROAD USAGE CHARGES IN THE U.S.

U.S. Department of Energy (DOE) analysis found that congestion pricing, combined with transit deployment and off-hours delivery policies, can provide a 14% improvement in system level efficiency, compared to the deployment of clean vehicles alone (Auld et al., 2024).

Oregon and Utah were the first two states to enact road usage charge programs in the US. Both programs were implemented as alternatives to the fuel tax as vehicles have become more fuel efficient and electric (UDOT, n.d.; ODOT, n.d.). Although neither program has published statistics on associated climate impacts, drivers in both states are expected to drive less often and drive fewer miles because of the VMT-based fees.

Today, nearly 35 states are either in the research or active stages of implementing RUC programs (ODOT, n.d.).

According to the Final Environmental Assessment for the New York City congestion pricing program, the program will reduce daily VMT within the Manhattan Central Business District (CBD) by at least 5% and reduce the number of vehicles entering Manhattan at 60th and below by at least 10% (MTA Congestion Relief Zone).

LOW EMISSIONS ZONES

A modeling study of a Low Emissions Zone in the Phoenix Metropolitan Area resulted in up to 4.5% reduction in fuel consumption when both eco-vehicle incentives and enhanced transit services, such as low fares and faster travel times, were offered. Eligible eco-vehicles would receive incentives ($0.50 to $1.50) for their use within the LEZ boundaries (Yelchuru et al., 2015).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Pricing programs that target downtown cores can reduce traffic in congested areas and lead to safety improvements for all road users (Singichetti et al., 2021).

> For example, estimated reductions in the number of road traffic crashes in Stockholm's zone-based charging area have been estimated at 3.6% per year, while London's zone-based charging area has led to an estimated 35% fewer crashes per month (Eliasson, 2009; Green et al., 2016).

COST SAVINGS

Transportation can be "repriced" in an equitable manner by converting fixed costs to variable costs. This saves travelers money while encouraging more efficient travel choices. Fixed transportation costs such as insurance premiums, vehicle taxes, and registration fees can be converted to variable costs by charging them on a per mile basis. Employer-provided parking converted to cash payouts similarly rewards travelers for more efficient choices. An FHWA study found that bundling six different repricing strategies could reduce vehicle miles traveled by 32% and save low-income drivers $460 per year (MAPC, 2019; Greenberg, 2024).

RUC programs may offer cost savings to people who drive less through discounted vehicle registration fees.

> For example, the Oregon RUC program provides a registration fee discount to electric and high-mpg vehicle owners and the Utah RUC program allows drivers to either pay per mile or pay a flat registration fee (ODOT, n.d.; UDOT, n.d.).

More fuel efficient and electric cars on the road means less in gas tax revenues for state governments. Road usage charges can help replace lost revenue and fund road, bridge, and tunnel maintenance and repair (Verra Mobility, 2022).

ECONOMIC GROWTH

Congestion pricing, sometimes called value pricing, harnesses the power of the market to reduce delay costs associated with traffic congestion. For example, the Texas Transportation Institute estimates that annual

congestion costs in the 15 largest urban areas ranged from $1,200 to over $3,000 per commuter in 2022 (TTI, 2024).

Congestion pricing and parking pricing can support fiscal responsibility while reducing on-road congestion and encouraging lower carbon intensity modes of travel that take up less road space. Pricing allows local communities and states to recapture some of the value associated with road maintenance and construction. As an example at the federal level, the heavy motor use tax generates revenue that goes towards maintaining federal highway infrastructure.

By 2030, as much as half of the revenue that could be generated from the gas tax will be lost as a result of increasing vehicle efficiency and electrification. Road usage charges can provide a more sustainable revenue source for public roads (Verra Mobility, 2022).

New York City congestion pricing program is expected to generate sufficient annual net revenues to provide $15 billion for capital projects for the MTA Capital Program (MTA Congestion Relief Zone).

See the Convenient Transportation: An Action Plan for Energy and Emissions Innovation for more information about the economic benefits of pricing programs.

ACCESSIBILITY AND EQUITY

Congestion pricing programs can include equity-related performance measures to ensure that they are not disproportionately harming lower income individuals or other disadvantaged communities.

A UC Davis review of congestion pricing strategies in North America and worldwide found that the most equitable programs include a meaningful community engagement process to help policymakers identify equitable priorities, pricing structures that balance efficiency and equity, while encouraging multi-modal travel, clear plans for investing congestion pricing revenues to balance the costs and benefits of congestion relief, and plans for comprehensive reporting and monitoring to ensure equity goals are met (D'Agostino et al., 2020).

Freight emissions disproportionately impact low-income people and communities of color who live near port facilities and industrial zones. Congestion pricing for freight can encourage mode choice to less polluting modes, like rail and maritime, wherever possible (AGU, 2021; Chen et al., 2018).

Pricing programs can be designed and implemented in such a way that reduces harm to vulnerable communities; for example, cities might consider expanding public transit and ramping up service before implementing driving fees. Cities can also offer discounts to low-income drivers and exemptions to persons with disabilities and certain classes of vehicles.

New York City's congestion pricing plan considers the impact for people with disabilities. People with disabilities, caregivers, or organizations that transport people with disabilities can apply to receive an exemption from the toll for a designated vehicle (MTA 2024).

> California investigated road charges as an alternative to the gas tax for funding transportation solutions. Findings from a 2015-2017 pilot showed that 73% of participants felt that a road charge was a more equitable approach compared to the gas tax (CalSTA, 2017).

AIR QUALITY AND HEALTH

Congestion pricing reduces traffic congestion, which in turn limits idling and stop-and-go behavior, leading to improvements in local air quality (FHWA, Congestion Pricing).

Pricing programs can encourage drivers to drive less and choose travel to off-peak hours. They can also promote a choice to less polluting modes. When coupled with low-emission zones and incentives for alternative fuel and electric vehicles, road pricing can have sizable local and regional air quality benefits.

Congestion pricing in New York City will provide a net air quality benefit to the region. The pricing program is expected to sharply reduce vehicles emissions in the CBD, an area that today has some of the worst air quality in the U.S. (MTA Congestion Relief Zone).

> In the City of London, NO_2 concentrations in central London are estimated to be 44% lower than they would have been without the ULEZ and its expansion (C40, 2022).
>
> The City of London used congestion pricing revenues towards the purchase of over 500 zero emission buses; as of 2021, all new buses must be zero emission (OECD, 2022).

COST CONSIDERATIONS

The cost to develop pricing programs and low-emission zones varies widely depending on the scale of the program coverage area.

Program costs include marketing and driver education, operations and maintenance, administrative costs, and enforcement costs.

The adoption of in-vehicle telematics, as a means for collecting mileage data, could dramatically reduce the impact of the adoption, administration, and enforcement costs of a road charge program (CalSTA, 2017).

Examples of congestion pricing revenues

Congestion charge net revenues from the City of London's program reached £307 million ($380M) in 2021/22. The ULEZ and LEZ generated a net income of £111 million ($137M) and £34 million ($42M) in 2021/22, respectively (Transport for London, 2022).

Stockholm's congestion pricing program has annual net revenues of approximately $155 million (SFCTA, 2020).

FUNDING OPPORTUNITIES

FHWA's **Value Pricing Pilot Program** provides tolling authority to State, regional or local governments to implement congestion pricing applications and report on their effects.

FHWA's **Congestion Relief Program**, established under BIL, provides competitive grant funding for programs that reduce congestion through pricing roadway use and parking, among other methods of decreasing congestion. This would have the benefit of encouraging other modes of travel that are less polluting and take up less road space, while recapturing some of the value associated with road maintenance and construction from those who use the roads most.

FTA's **Capital Investments Grant Program** funds transit capital investments, including heavy rail, commuter rail, light rail, streetcars, and bus rapid transit. Capital investment grants can be used to support public transit improvement potentially in concert with revenues from congestion pricing programs.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including carpool and vanpool projects.

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COMPLEMENTARY STRATEGIES

Coordinated transportation planning helps identify where congestion pricing strategies could be most effective and ensures that alternative transportation options are available to commuters affected by pricing measures. Additionally, revenue generated from congestion pricing can be reinvested into transportation infrastructure and services, further supporting coordinated planning efforts. Ultimately, both strategies complement each other to promote more sustainable transportation choices.

Road usage charges and other pricing programs that charge higher tolls during peak hours may encourage carriers to shift deliveries to off-peak hours.

By implementing zoning codes that prioritize compact, walkable neighborhoods with access to public transportation, communities can create environments where congestion pricing measures are more effective.

Travel demand modeling plays a critical role in assessing the effects of cordon and congestion pricing on transportation systems. By analyzing how pricing schemes influence travel behavior, such as encouraging carpooling, using public transit, or shifting travel times, planners can anticipate changes in demand for road space. This understanding helps design effective congestion pricing strategies to manage traffic flow and reduce congestion while considering potential induced demand effects.

View All Strategies

CASE STUDIES

CALIFORNIA ROAD CHARGE PILOT

The California Road Charge Pilot Program operated over a 9-month period in 2016-2017 to investigate a long-term sustainable replacement to the gas tax. It was managed by Caltrans and involved over 5000+ vehicles statewide and 37+ million miles. The pilot included private vehicles and commercial vehicles and collected data via a combination of manual and automated reporting methods. The California State Highway Administration released pilot findings in 2017: 75% of participants felt a road charge was a more equitable transportation funding solution than the gas tax and the majority of participants were more aware of their typical mileage and the amount they pay for road maintenance. A follow-on pilot is planned for 2024-2025 to further explore RUC as a policy idea.

LEE COUNTY, FLORIDA: BRIDGES VARIABLE PRICING

Lee County, Florida, which includes the Fort Myers and Cape Coral metropolitan areas, has used variable bridge tolls to manage congestion since 1998. The objectives of the program are to provide travelers with an incentive to travel during non-peak periods, lower out-of-pocket transportation costs, and encourage the use of electronic tolling. Tolls are charged at three bridge points: a midpoint plaza, Cape Coral Plaza, and Sanibel Island Plaza. The tolling program includes significant discounts for traveling during off-peak hours and using electronic transponders.

NEW YORK CITY CONGESTION PRICING

New York City is the first city in the United States to charge all motorists for driving in its congested core. The Central Business District Tolling Program, which went into effect in January 2025, is projected to result in significant VMT reductions from 60th Street to the southern tip of the Financial District in Manhattan. The Metropolitan Transit Agency estimates that there will be 80,000 fewer vehicles entering the zone every day. The program includes flat fees for passenger vehicles and motorcycles, fees for trucks depending on size, and surcharges for taxis and rideshares. The congestion pricing program will also support improvements to transit service using the expected increase in transit ridership and associated increase in transit revenues.

INTERNATIONAL CONGESTION PRICING EXAMPLES

City of London Congestion Charges and Low-Emission Zones

The City of London's congestion charges, in addition to other improvements, have helped London achieve a significant modal optionality. By 2019, trips by private car were about 15% below 2000 levels, and the city saw increases across the board in public transit use, walking, and biking (OECD, 2022; C40 Cities Climate Leadership Group, 2022).

The City of London's Low Emission Zone (LEZ) for heavy goods vehicles and Ultra Low Emission Zone (ULEZ) for trucks and residential vehicles have been highly successful in discouraging older, more polluting vehicles (particularly diesel cars) from entering inner London and promoting a choice to cleaner vehicles. In 2022, over 90% of vehicles driving in the ULEZ meet emission standards on an average day and over 80% meet the standards in outer London. The London ULEZ specifically has reduced CO_2 emissions from transport in the zone by around 6% (OECD, 2022; C40 Cities Climate Leadership Group, 2022).

Despite approximately a 20% increase in population, traffic congestion in the City of London has remained stable since congestion charges were first implemented in 2003, at about 20 billion vehicle miles per year. During peak hours specifically, the new ULEZ has helped to ease congestion with around 13% fewer vehicles on the roads (OECD, 2022).

Stockholm Congestion Charges

Since Stockholm's congestion charges went into effect in 2007, the city has seen a 14% decrease in transportation related GHG emissions (SFCTA, 2020). In the first decade of Stockholm's congestion pricing program being active, the city's population increased by 10% while traffic levels decreased by 22%. In parallel, the city's public transit system has seen a 5% increase in ridership. (SFCTA, 2020).

IMPLEMENTING ROAD PRICING STRATEGIES: **WHAT TO READ NEXT**

FHWA Resources on Road Pricing

FHWA's Road Pricing resources include information on Freight and Port Pricing, Pricing of HOV Facilities, Express Lanes, and various USDOT-sponsored VMT fee and congestion reduction demonstrations.

FHWA's Congestion Pricing Website provides information and resources to help equip state agencies and practitioners with tools to implement congestion pricing projects and incorporate pricing into transportation planning.
See Congestion Pricing: A Primer.

Road Use Charges

RUC America provides resources and funding for projects related to the feasibility and implementation of RUC programs.

California Road Charge Pilot: The website for California's Road Charge Pilot provides helpful pilot study and other research findings, including impacts to communities.

- 2017 Pilot Findings
- 2024-2025 Pilot Study

Fare Collection Technology

The same technology used for electronic and open road tolling (overhead gantries, transponders, etc.) can also be used for pricing programs.

Automated reporting methods include (CalSTA, 2017):

- Plug-in Device – reports miles electronically with a device that plugs into a vehicles data (OBD-II) port
- Smartphone (with and without location awareness) – reports miles using a smartphone app
- In-Vehicle Telematics – reports miles using technology integrated into vehicles

RESOURCES

GENERAL RESOURCES

RUC America: This organization brings together statement transportation organizations to share best practices and research on road usage charges.

FHWA Road Pricing: The website includes resources on Freight and Port Pricing, Pricing of HOV Facilities, Express Lanes, and various USDOT-sponsored VMT fee and congestion reduction demonstrations.

FHWA Congestion Pricing Website: The website provides information and resources to help equip state agencies and practitioners with tools to implement congestion pricing projects and incorporate pricing into transportation planning. See Congestion Pricing: A Primer for a quick reference on value pricing strategies.

C40 How to Design and Implement a Low Emission Zone: C40 offers an implementation guide for low emission zones, including the benefits of these zones, information on information on policy options, design considerations, and strategies to address challenges.

NYC MTA Congestion Relief Zone: The New York Metropolitan Transportation Authority (MTA) Congestion Relief Zone website provides information on the State's Congestion Pricing program. The website includes information on tolling zones, toll structure, discounts and exceptions, and frequently asked questions.

TOOLKITS AND MODELING APPROACHES

National level

EPA Motor Vehicle Emission Simulator (MOVES): This resource provides vehicle emission rates and mobile-source inventories.

Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Modele: The model provides life-cycle emissions assessment for different vehicle technologies and futures.

State level

Sonoma County Vehicle Miles Traveled Reduction Calculator: The calculator can be used to evaluate the effectiveness of mitigation measures on the transportation effects of land use projects under the California Environmental Quality Act (CEQA).

California Quantifying the Effect of Local Government Actions on Vehicle Miles Traveled (VMT): This research resulted in a Vehicle Miles Traveled (VMT) Impact spreadsheet tool, which lets users easily see impacts for any census tract, city, or region in California.

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U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

SHARED MICROMOBILITY & MICRO TRANSIT

Shared and electric micromobility offer convenient, flexible, and clean travel options while improving public health and addressing gaps in urban mobility.

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OVERVIEW

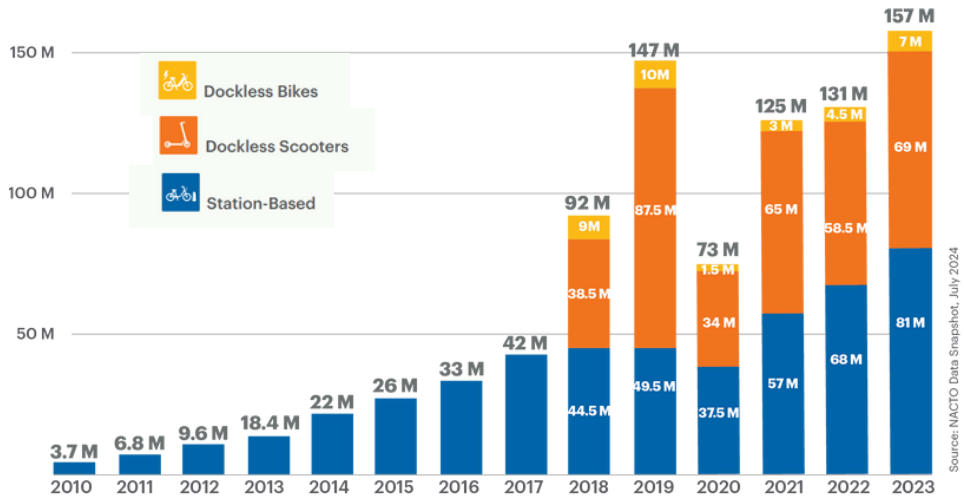
Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural, & Tribal

Shared micromobility is defined as small, lightweight human-powered or electric vehicles operated at low speeds, such as docked and dockless e-scooters and bikeshare systems. According to the National Association of City Transportation Officials (NACTO) (2024), **people in the United States took more than 133 million trips on shared bikes and e-scooters in 2023**, an increase of 17% since 2022 and nearly 10-fold increase from 2013.

Most shared micromobility trips are 15 minutes long and average 1.5 miles. Shared micromobility has a role to play in transportation decarbonization by increasing access to low-carbon transportation modes.

Shared bikes and e-scooters are **particularly useful for first and last mile connections to public transit, for people without access to a personal bike or scooter or without the space required to store them, for one-way trips, and for visitors and tourists.** These systems have become an increasingly common and vital part of the transportation ecosystem.

Micromobility systems can be station-based or "dockless," as well as have different ownership models. The longest running and most-heavily used systems in the U.S. and Canada operate as public-private partnerships or city-run nonprofits. Programs that offer adaptive bike share options can better serve the disabled community. Ideally, shared micromobility systems go hand in hand with safe and accessible bike networks, including bike lanes, trails, and protected bikeways. Bike share has become increasingly popular, leading to a greater need for multimodal streets that accommodate walking and biking at different speeds, in addition to room for personal and public transit vehicles.



Shared Micromobility Ridership in the U.S. 2010-2023 (Source: NACTO, 2024)

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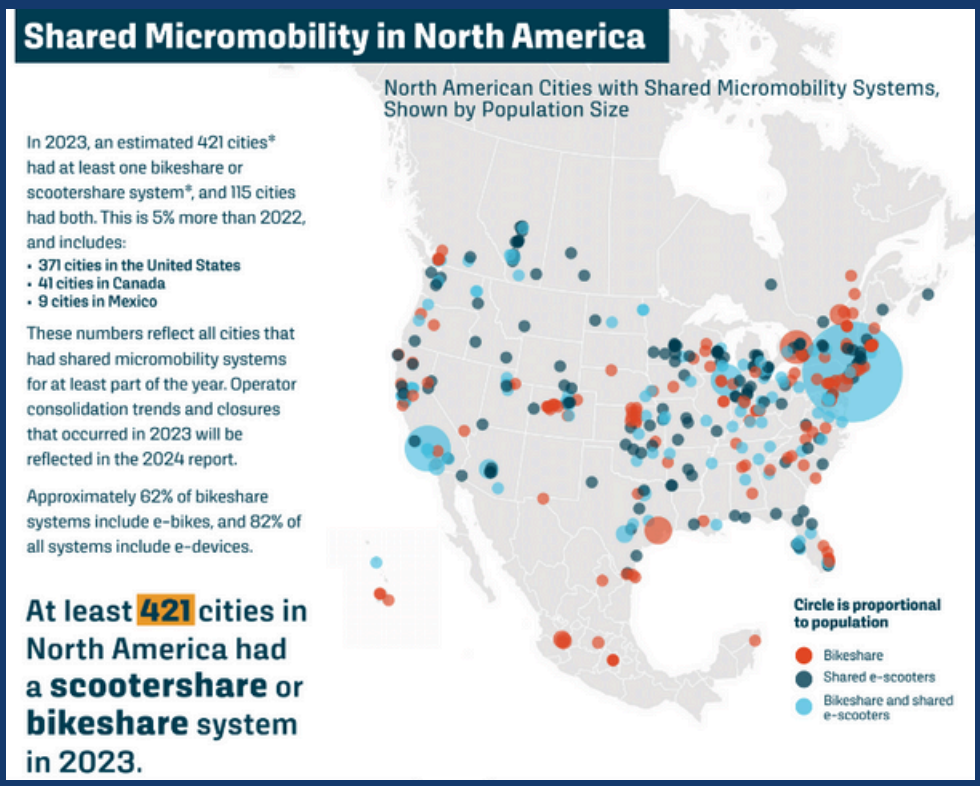
Microtransit is defined as small-scale, on demand public transit services that that can offer fixed routes and schedules, as well as flexible routes and on-demand scheduling (APTA, n.d.). Microtransit may serve populations with unique needs, such as seniors and people with disabilities, rural communities with less capacity for robust public transportation network infrastructure, or highly dense urban areas with limited public transit options.



According to NACTO, the five longest-running and highest-ridership shared micromobility systems in the U.S. and Canada are:

- BIXI (Montréal)
- Bluebikes (greater Boston)
- Capital Bikeshare (greater Washington D.C.)
- Citi Bike (NYC, Jersey City, and Hoboken)
- Divvy (Chicago and Evanston)

Source: (NABSA, 2023)

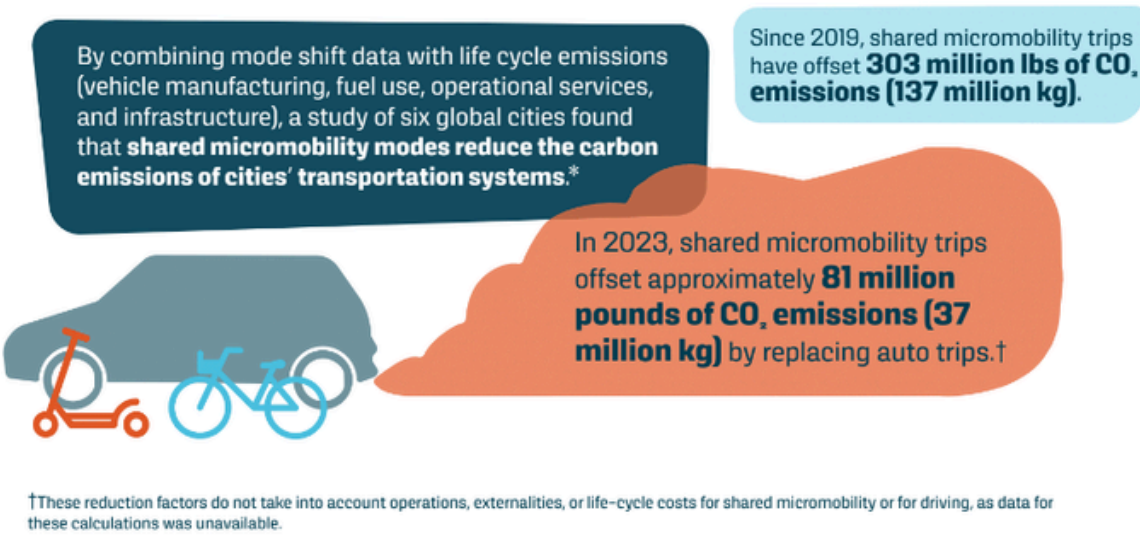
GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

SHARED BIKES AND SCOOTERS REPLACE CAR TRIPS AND REDUCE EMISSIONS

The U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL) found that at peak adoption, shared micromobility can save the equivalent of 2.3 billion gallons of gasoline per year nationwide (NREL, 2021).

In 2023, shared micromobility offset approximately 81 million pounds of CO_2 emissions (37 million kg) by replacing car trips. Thirty-seven percent of shared micromobility trips continue to replace car trips, and 70% of riders report that they used shared micromobility to connect to transit. In these ways, shared micromobility is a powerful climate action tool that helps to decarbonize transportation (NABSA, 2024).



Source: (NABSA, 2023)

Recent modeling by NREL found that by expanding access to shared electric bicycles and electric-assist bicycles (e-bikes) in Los Angeles to meet demand could reduce citywide vehicle miles traveled (VMT) by about 5%, GHG emissions by about 316,000 tons of CO_2e and electricity demand by about 187 GWh when compared to light duty EVs (NREL, 2021).

In a study of shared micromobility in six global cities, shared e-scooters and e-bikes provide net emissions benefits compared with other modes, particularly trips replacing ridehailing, personal car use, and carshare. For example, shared e-bikes provide a net CO_2e benefit per trip of 679 grams (Krauss et al., 2022).

Using Seattle as a model, researchers found that 18% of short car trips could be replaced by micromobility, reducing congestion on heavily driven urban roadways (Fan and Harper, 2022).

As part of a recent State of the Industry report, the North American Bikeshare and Scootershare Association (NABSA) conducted a user survey and found that 37% of shared micromobility trips replace a car trip (NABSA, 2024).

ON-DEMAND MICRO TRANSIT, INCLUDING ELECTRIC SHUTTLES, PROVIDE A CLEANER ALTERNATIVE FOR SHORT CAR TRIPS

In San Diego, the 'FRED' (Free Ride Everywhere Downtown) local shuttle program, launched in August 2016 in partnership with Circuit, reduces CO_2 emissions by 110.5 metric tons a year.

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Investments in and the expansion of active transportation infrastructure for micromobility users are proven safety countermeasures promoted by Federal Highway Administration (FHWA) for reducing roadway fatalities and serious injuries.

See other FHWA Safety Countermeasures here.

Investment in active transportation can promote the perception and reality of safety. A higher volume of people walking, cycling, and scooting fosters a stronger sense of community (USDOT, n.d.).

Communities designed with pedestrians, bicyclists, and other micromobility users in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways. Safer streets and connecting trails can, in turn, encourage choices towards active transportation (USDOT, n.d.).

ECONOMIC GROWTH

Communities with well-connected active transportation networks and options for micromobility experience increased foot traffic, which translates to economic benefits for local businesses (Litman, 2024).

Investing in active transportation infrastructure creates jobs. International Energy Agency (IEA) data suggests that pedestrian and bike lanes generate 8 to 22 jobs for every million dollars spent. These jobs typically involve construction, painting, signage installation, and paving (IEA, 2020).

AIR QUALITY AND HEALTH

Reducing the number of emissions-emitting vehicles on the road (especially in densely populated areas) will decrease air pollutants that are harmful to human health (Sax, 2024).

Shared scooters, bikes, and other shared individual vehicles can bridge the last-mile gap, reducing traffic and congestion, which in turn reduces exhaust emissions that are harmful to health (EPA, 2014; Sax, 2024).

ACCESSIBILITY AND EQUITY

Shared e-scooters have a high potential to be a last-mile solution to transit. People of color, who have been historically underserved by the transportation system nationally and have lower access to emerging transportation modes, use shared e-scooters to connect with transit more frequently (Huang et al., 2024).

Shared micromobility operators and regulators have prioritized equitable access to micromobility facilities. 90% of North American systems offer discount programs, 72% offer alternative payment options, 67% incorporate geographic distribution policies, and 69% offer education and outreach programs (NABSA, 2024).

In a survey of NACTO member cities, income-based discounts were available in nine out of ten (91%) station-based systems and two out of three (67%) dockless systems. These programs have become increasingly common since 2016, when only 24% of shared micromobility systems offered income-based subsidies (NACTO, 2024).

Most shared micromobility services are app based, a disadvantage for individuals without smartphones, bank accounts, or credit or debit cards. To ensure that these devices remain accessible to all, micromobility operators can provide additional payment options (FHWA, 2022).

Shared micromobility operators can offer adaptive devices for individuals with physical disabilities who may be unable to ride traditional stand-up scooters or bicycles. Adaptive devices can take the shape of seated scooters, recumbent bicycles, hand-pedaled cycles, powered cycles that attach to wheelchairs, and others. Read about the San Francisco Municipal Transportation Agency's adaptive bike share program here.

Shared micromobility operators rebalance – or relocate – devices daily to meet public demand at different times and locations. Micromobility operators can use this regular process to ensure that they rebalance devices to areas that are underserved and disadvantaged (FHWA, 2022).

RESILIENCE AND ADAPTATION

Expanding access to micromobility can reduce the need for dedicating space to vehicle movement and storage, which can in turn enable other uses of limited urban land area (USDOT, 2023).

COST SAVINGS

Income-based pricing is a key component of ensuring equitable access to shared micromobility options. When shared micromobility trips are less expensive than riding the bus, particularly when buses connect to transit, they become more realistic options for price-sensitive riders (NACTO, 2023).

In 2022, the average cost of a 1.5-mile trip for regular bike and e-bike systems ranges from $2.30 to $5.50 depending on membership and pay-by-ride options. These costs are significantly less than average ridehailing and taxi rides in most cities for the same distance (NATCO, 2023).

Cost of typical shared micromobility trips (Source: NACTO, 2023)

The average cost of discounted memberships averaged $3.25 per month in 2022, with some systems costing as little as $5 for the entire year.

COST CONSIDERATIONS

There are several business and funding models available within shared micromobility. Typically, shared bicycle systems in the U.S. are public-private partnerships, while scooter shares are for-profit ventures.

Some systems require investment and cost-sharing from local governments, especially station-based, or "docked" systems that are most suitable for large, dense cities. Dockless systems tend to be lower-cost or free for local governments and may require private micromobility companies to pay the municipality/region/state for an operating permit.

COST OF IMPLEMENTATION

Costs of a shared micromobility project include administrative, capital equipment costs, and operation and maintenance costs. Capital costs for micromobility devices range from $400-800 for a non-electric bicycle up to $3,000-4,000 for electric bicycles. Docking stations, depending on features and station size, cost between $30,000 and $60,000 (Clean Mobility Options, 2022).

The estimated annual cost for the Dockless Micro-mobility Pilot Program in West Hollywood in FY21-22 was approximately $200,000, not counting staff time. This includes $170,000 for operations and $30,000 for capital. The program generated a revenue of $90,000 from operator permit fees which were directed to the city's General Fund (West Hollywood City Council, 2022).

The City of Boston proposed allocating $2 million in 2024 for its Bluebikes system, with funds specifically earmarked for discounted passes and for buying the system's first electric pedal-assist bikes (MilNeil, 2023).

FUNDING OPPORTUNITIES

FHWA compiles pedestrian and bicycle activities and their likely eligibility under U.S. Department of Transportation surface transportation funding programs in this table.

FHWA's **Congestion Relief Program**, established under BIL, provides competitive grant funding for programs that reduce congestion through pricing roadway use and parking, among other methods of decreasing congestion. This would have the benefit of encouraging other modes of travel that take up less road space, such as shared micromobility, while recapturing some of the value associated with road maintenance and construction from those who use the roads most.

FHWA's **Carbon Reduction Program** (CRP) funds projects designed to reduce transportation carbon dioxide (CO_2) emissions from on-road highway sources. CRP funds can be used for a variety of micromobility and active transportation projects.

FHWA's **Congestion Management and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The BIL continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including shared micromobility projects.

FHWA's **Active Transportation Infrastructure Investment Program (ATIIP)** supports planning and active transportation implementation (mobility options powered primarily by human energy, including bicycling and walking) at the network scale, rather than on a project-by-project basis. Improvements in active transportation networks under ATIIP will expand and improve active transportation and promote it as a low-emissions transportation option.

FHWA's **Surface Transportation Block Grant (STBG) Program Transportation Alternatives Set-Aside** requires FHWA to sets aside 10% of national STBG funds for a variety of smaller-scale transportation projects such as pedestrian and bicycle facilities; recreational trails; safe routes to school projects; vulnerable road user safety assessments; and active transportation projects.

FTA's **Local Match Waiver for Complete Streets** waives the non-federal match for the Metropolitan Planning Program and the State Planning and Research Program for Complete Streets planning activities, such as sidewalks, bicycle lanes, bus lanes, public transportation stops, crossing opportunities, median islands, accessible pedestrian signals, curb extensions, modified vehicle travel lanes, streetscape, and landscape treatments. This waiver provides incentives for applicants to undertake complete streets projects, improving opportunities for shared micromobility.

USDOT's **Reconnecting Communities and Neighborhoods (RCN) Program** provides grants to improve multimodal transportation access, to foster equitable development, and to remove, retrofit, or mitigate highways or other transportation facilities that create barriers to community connectivity. Projects that improve walkability, safety, and affordable transportation access are eligible for funding.

COMPLEMENTARY STRATEGIES

Shared micromobility services complement active transportation networks by offering convenient, low-barrier options for short-distance trips, thereby encouraging individuals to choose sustainable modes of transportation and reducing reliance on private vehicles.

Coordinating transportation planning activities across sectors, jurisdictions, and levels of government provides more opportunities to support shared micromobility as a low- and no-emission transportation option.

Micromobility delivery services rely on shared micromobility systems. Leveraging bicycles and scooters for last-mile deliveries, these services contribute to the efficient movement of goods while complementing efforts to reduce traffic congestion and emissions in urban areas.

Trip planning and modal integration techniques, including new technology platforms, can improve access to linking public transit services with shared micromobility.

View All Strategies

CASE STUDIES

SHARED MOBILITY SERVICES PILOT - SANTA MONICA, CA

Santa Monica, CA began a Shared Mobility Services Pilot in 2018 allowing four private companies to provide shared mobility services, including e-scooters and e-bicycles, to the community. The city carefully crafted the program to enable flexibility and collaboration with the participating companies in order to encourage data sharing, equity, and accessibility within the system.

Source: City of Santa Monica.

Findings from the pilot indicate that 49% of shared mobility trips replaced trips that otherwise would have been driving or ride-hailing, showing the program's success in reducing congestion and emissions.

E-SCOOTER PILOT AND BIKESHARE EXPANSION - CHICAGO, IL

Chicago Department of Transportation (CDOT) committed to expanding its shared micromobility program in 2019. CDOT launched an e-scooter pilot and expanded the city's Divvy docked bikeshare program, adding 10,500 new electric-assist bikes and 175 new stations. CDOT coordinated extensively with community partners during this expansion to provide traditionally underserved communities with improved access to shared micromobility devices. A report on Chicago's e-scooter pilot found they fill a mobility gap for lower-income residents and help travelers choose active transportation.

Spotlight on Kansas City

Shared micromobility operators provide eligible users with prepaid passes so that they do not need to use a credit card to pay for scooter use.

GOTCHA BIKESHARE - BATON ROUGE, LA

In partnership with East Baton Rouge City-Parish and Blue Cross and Blue Shield of Louisiana, Gotcha has launched Baton Rouge's bike share program, featuring 500 electric pedal-assist bikes across 50 mobility hubs in the city, LSU, and Southern. The initiative aims to provide an accessible and affordable micro-transit option, promoting active mobility and contributing to the city's smart city objectives. With 50 hub locations, riders can access bikes through the Gotcha app, facilitating reduced traffic congestion, shortened trip times, and enhanced tourism. Sponsors and partners, including Blue Cross and Blue Shield of Louisiana, Baton Rouge General, and academic institutions, contribute to the success of the program. The bike share system supports health, sustainability, and community connectivity, aligning with Baton Rouge's commitment to improving lives and reducing traffic-related challenges.

Source: SMILIES (Shared MicromobIlity for affordabLe-accessIbIE houSing)

Source: Baton Rouge Downtown Development District

ENHANCING MOBILITY ACCESS FOR LOW-INCOME RESIDENTS - FORT SMITH, AR

In Fort Smith, Arkansas, a shared micromobility pilot program was launched to address transportation challenges faced by low-income residents, who often lack reliable public transit options. Funded by a $1.2 million grant from the National Science Foundation, the program introduced 40 bikes, including electric and traditional options, strategically placed in low-income neighborhoods to improve access to jobs and essential services. As of April 2024, the pilot has logged over 12,000 miles with 60% of trips taken by low-income users, and 36% of surveyed participants indicated they would have used a personal vehicle for their trips.

E-BIKE LIBRARIES - DENVER, CO

Denver has established shared e-bike libraries in the Globeville and Elyria-Swansea neighborhoods, funded by a $40 million annual Climate Protection Fund. These libraries provide free e-bikes to low-income residents, addressing the area's limited transit options while promoting sustainable transportation. In their first full year, the libraries served approximately 40 members, who collectively rode over 18,922 miles, with 28% of their trips replacing car journeys. Additionally, participants reported significant improvements in their ability to access jobs and essential services, underscoring the program's impact on daily mobility and community health.

Source: Northeast Transportation Connections (NETC)

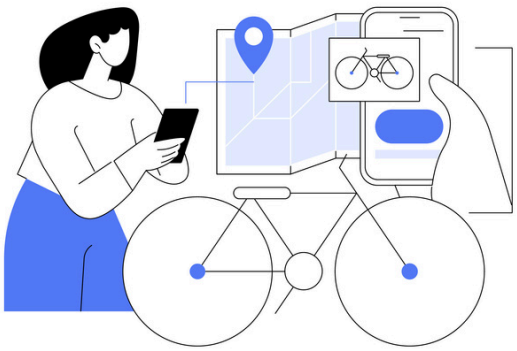
IMPLEMENTING SHARED MICROMOBILITY & MICRO TRANSIT: **WHAT TO READ NEXT**

Over 360 cities and counties in the United States already have shared micromobility systems – the technology is well-proven and readily available. As a good starting point, see NABSA's webinar on "Shared Micromobility 101: Foundations and Tips for Setting up a Shared Micromobility System". The webinar includes information on system design principles, outlines different business and operating models along with funding questions and recommendations, and best practices in community engagement.

For a deeper dive into shared micromobility, read NACTO's 2023 Shared Micromobility in the U.S. and Canada Report and NABSA's 2023 State of the Industry Report.

USDOT provides several resources on shared micromobility, including:

- FHWA Micromobility Webpage
- Shared Micromobility and Equity Primer
- Proven Safety Countermeasures – see the Pedestrian/Bicyclist Countermeasures
- Interactive Bikeshare and e-Scooter Map
- Urban E-Mobility Toolkit



In 2021, the City of Denver established successful private-public partnerships with micromobility companies to operate dockless bikes and e-scooters. Shared micromobility ridership in Denver grew to 5 million registered trips in 2022, 13 times that of the previous station-based bicycle system. See the following resources:

- Denver's Scooter and Bike Share Program (includes information on Equity and Discounted Pass Programs)
- FHWA Livability Feature on E-Bikes and Equity and Climate Goals
- Denver Ride Report: Micromobility Dashboard

The Mobility Project Implementation Toolkit, designed by California's Clean Mobility Options Program, helps state and local governments implement mobility projects. It guides users through budgeting, hiring decisions, and community engagement, helps with procurement and contracting, and assist with site selection.

Bike or e-bike lending libraries are often run by community-based organizations or public libraries to provide free or low-cost access to bikes or e-bikes for different periods of time (e.g., from hours to several weeks or months). Read more about starting an e-bike library, and about the Athens County Public Libraries Book-a-Bike program.

RESOURCES

GENERAL RESOURCES

FHWA Strategic Agenda for Pedestrian & Bicycle Transportation (2024-2028): This resource charts a roadmap of activities that support active transportation initiatives for the next 5 years.

FHWA Bicycle and Pedestrian Program webpage: This webpage includes resources on micromobility.

The Bureau of Transportation Statistics Docked Bikeshare Ridership Map: The map currently includes 2020-2023 monthly counts for 14 bike share systems.

North America Bikeshare and Scootershare Association (NABSA) provides several resources related to shared micromobility including:

- Foundations and Tips for Setting Up a Shared Micromobility System webinar: The webinar includes an overview of shared micromobility, system design principles, system setup, community engagement best practices, and case studies.
- Incorporating Shared Micromobility in Electric Vehicle Charging Projects: This publication explored the benefits of incorporating shared micromobility in EV charging projects.
- 2023 State of the Industry Report: This annual report provides the state of shared micromobility in the United States.

National Association of City Transportation Officials' 2023 Shared Micromobility in the U.S. and Canada Report: This annual report provides shared micromobility statistics and trends across the United States and Canada.

Better Bike Share Partnership Resources: This website offers a range of shared micromobility resources including case studies, conference presentations, one-pagers, videos, research and reports, sample materials, and toolkits.

National League of Cities' Micromobility in Cities: The Current Landscape: This resource provides an overview of shifts in micromobility, how micromobility works in cities, equity considerations, and case studies.

Environmental Protection Agency (EPA) provides several resources related to micromobility:
Smart Growth website: This website hosts resources to help local governments and community leaders. For example, the Smart Location Database contains metrics that enable evaluation of the relative transportation emissions associated with specific sites.

Green Infrastructure website: This website includes resources to help communities design and build streets that incorporate trees, plants, and other green infrastructure techniques to make active transportation more pleasant while also providing multiple other benefits.

Travel Efficiency Assessment Method (TEAM): This resource provides a framework to estimate the potential future emission reductions. The program includes more than 75 DOE-designated coalitions act locally in urban, suburban, and rural communities across the country.

Complete Trip ITS4US Program: This $40 million multimodal effort is led by the ITS JPO and supported by the USDOT Office of the Secretary, Federal Highway Administration, and Federal Transit Administration jointly working to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers. This program prioritizes an individual's ability to travel from origin to destination without using a personal vehicle and without encountering gaps in the travel chain.

US DOT Technical Resources for Active Transportation Planning Design and Implementation: This website provides a range of relevant technical resources including guidance on procurement, pilot funding, project development assistance, and direct assistance in preparing Federal grant applications.

TOOLKITS AND MODELLING APPROACHES

Shared-Use Mobility Center: Shared Mobility Benefits Calculator: This calculator is a tool for cities to estimate the emissions benefits from deploying various modes of shared mobility. Using these estimates, policymakers can envision and set goals towards reducing congestion, household transportation costs, and carbon emissions from personal vehicles.

FHWA CMAQ Toolkit: This toolkit includes a Shared Micromobility tool to estimate the emissions benefits of shared bike and shared scooter projects.

RMI's E-Bike Impact Calculator Tool for Local Governments: The e-bike calculator estimates the impact of e-bikes as a substitute for short vehicle trips; it also estimates the impact of an e-bike incentive program. Impacts are provided in terms of GHG emissions and VMT reductions, as well as cost savings.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

TRANSIT ORIENTED DEVELOPMENT (TOD)

Transit-oriented development connects neighborhoods and communities with equitable and accessible public transit and multimodal transportation options, reducing trip distances, vehicle miles traveled, and associated greenhouse gas emissions.

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OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban

Supporting mixed-use development, including affordable housing, near transit can **reduce trip distances and make public transportation more convenient**. Transit oriented development (TOD) is usually defined as development within a half mile of transit. TOD can also make accessing common destinations and public services like grocery stores, schools, and libraries easier. In a suburban context, co-development of increased housing density and transit stations with active transportation infrastructure offers **a way for commuters to reach their destinations without needing to rely on personal vehicles**. In rural town centers, TOD could involve constructing housing adjacent to intercity rail or intercity bus terminals.

Transit oriented development **reduces dependence on cars, eliminates costs of car ownership, and encourages use of public transit, walking, and biking**. Transit oriented development may also **reduce traffic congestion** by supporting full mode choice and an increased sense of community.

Did you know?

At the project scale (no greater than a census tract), TOD has the potential to reduce GHG emissions by 31% (CAPCOA, 2021).

Creating new transit-oriented housing and development **involves long term planning** at the city or local government level, and is often supported by comprehensive urban development, land use, and transportation plans. Supply and diversity of land use and local zoning regulations are important elements of planning and implementation of TOD. Mixed-use development, for example, includes commercial spaces, which require **alignment with zoning policies, supportive market conditions, and private sector collaboration** in order to be financially viable. Housing demand, affordable housing requirements, neighborhood effects, and accessibility are additional considerations.

Homes in walkable and transit-accessible areas are extremely desirable, and insufficient supply generally leads to higher prices for these homes. Increasing the amount of development near transit **enables lower housing costs and makes more convenient transit service available for residents of all incomes**. Pairing TOD with a diverse mix of housing and infill development can also help **avoid displacement** of existing residents and allow them to access the same economic benefits.

Increased housing demand, increased cost of living, lack of housing production, and other market factors can lead to increases in property values with TOD. **Equitable transit-oriented development (ETOD)** is an approach to address these outcomes, **through the inclusion of affordable housing near transit to make public transportation more accessible and available for all users within a community.** ETOD also involves addressing additional discriminatory impacts, prioritizing community involvement, and ensuring inclusion of underserved groups in decision making processes. ETOD aims for transit to be relevant and beneficial to all people within a community, regardless of income or other factors.

> The U.S. Department of Transportation (USDOT) released a Policy Statement on TOD that encourages TOD projects to consider public benefit provisions such as anti-displacement strategies and increased supply of affordable housing. The policy statement provides project developers with guidance on strategies to ensure equitable housing practices for TOD, and compliance could be used in the future as a condition for certain discretionary funding programs.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

GHG BENEFITS OF COMPACT DEVELOPMENT

Sites with high walkability, mixed uses, and high-frequency transit service have lower emissions compared with less accessible sites (CSG, 2020).

At the project scale (no greater than a census tract), analysis done by the California Air Pollution Control Officers Association found that TOD has up to a 31% GHG emissions reduction potential. The analysis assumed that TOD sites were within a 10-minute walk of a high-frequency transit station and a 4.9 ratio of transit mode share compared to existing transit mode share in the surrounding city (CAPCOA, 2021).

An RMI analysis using 2023 data shows that enacting state-level land use reform to encourage compact development can reduce annual CO_2-equivalent emissions by 70 million tons in 2033. About one half of this reduction would come from reduced travel, a third from reduced vehicle manufacturing and upstream fossil fuel production, and the remainder from preservation of natural carbon sinks that would otherwise be lost to urban sprawl and use of more efficient, lower-carbon building materials (Korn et al., 2024).

> TOD can be implemented on a variety of scales, from an office park to single neighborhood to an entire town or city center. In Alexandria, VA, the Braddock Metro Neighborhood Plan focused on better integrating the Braddock Road metro station into the neighborhood through improved pedestrian connectivity and mixed-use redevelopment. Analysis by the Coalition for Smarter Growth found that implementing the plan resulted in a 27.1% reduction in CO_2 emissions compared with a nearby non-TOD area (CSG, 2020; City of Alexandria, 2008).

The largest opportunity for GHG reduction is in states with the most severe housing shortages and largest anticipated population growth. For example, in Texas, Colorado, and North Dakota, land use reforms could reduce statewide vehicle miles

traveled (VMT) per capita by up to 9%, or between 400 and 800 kg of CO_2 per capita annually (Korn et al., 2024).

Smart growth strategies, including TOD, typically reduce energy consumption and emissions by 10% to 60%, particularly if integrated with complementary strategies like vehicle electrification (Litman, 2024d).

COMPACT, MIXED-USE DEVELOPMENT CAN REDUCE CAR RELIANCE

GHG emissions and vehicle miles traveled (VMT) are interconnected and one of the most effective ways to reduce VMT is by building transit-oriented communities. In the U.S., a recent survey found that transit-oriented communities averaged 17 to 25.5 VMT and 16-25 lbs. of daily CO_2 emissions per household, compared with 45 VMT and about 70 lbs. of daily CO_2 emissions for non-TOD communities (CSG, 2020).

A review of studies looking at the link between transit proximity and driving found VMT reductions ranging from 3.0 to 9.0 VMT per passenger mile (Ali et al., 2021). Doubling density has been shown to reduce vehicle travel from 5% up to about 20% (Litman, 2024d).

When determining parking volumes for a property, many developers reference the guidelines for vehicle trip generation and parking volumes provided by the Institute of Transportation Engineers (ITE) Trip Generation Manual and ITE Parking Generation Manual. However, these manuals were created using data from suburban areas with little access to transit, so they tend to overestimate the trip and parking generation at TODs, where residents have more mode choice (Ewing et al., 2017; Ewing et al., 2018). A study of trip generation rates across 17 TODs determined that, on average, the A.M. peak hour vehicle trip generation rate for TODs is only 51.3% of the rate estimated by ITE (Arrington & Cervero, 2008). Additional case studies of specific TODs revealed trip generation rates that are 34.7% to 69.8% of the ITE rate (Ewing et al., 2017; Ewing et al., 2018).

An analysis of FHWA data on urbanized areas (FHWA, 2018) demonstrates the inverse relationship between per capita VMT and population density. The largest decline in per capita VMT results from going from low density (less than 2,000 residents per square mile) to moderate density (more than 4,000 residents per square mile) (Litman, 2024d).

Residents of TODs typically own 20-60% fewer vehicles, driver 20-40% fewer miles, and use non-auto modes 2-to-10 fold compared with more auto-oriented areas. When TOD includes improvements in active transportation conditions, residents also walk 2-4 times more (Litman, 2024a).

> In Denver, development of new transit facilities has had immediate and significant impacts on land use and housing density. Between 2000 and 2006, housing density increased from 1,379 to 1,429 units per km^2 and use of non-car modes increased by 61% (Ali et al., 2021).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

In the U.S., pedestrian and cyclist fatalities make up close to 20% of total annual traffic fatalities (Patnala et al., 2024). Communities designed with pedestrians, transit riders, bicyclists, and other micromobility users in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways. Safer streets and connecting trails can, in turn, encourage further shifts towards active transportation.

Investment in active transportation with TOD can promote the perception and reality of safety. Safe and comfortable walking and biking infrastructure can also reduce the likelihood of vehicle-pedestrian and vehicle-bicycle fatalities and serious injuries (Boutros et al., 2023).

Residents of TOD communities typically have 20-80% lower per capita traffic fatality rates as the same demographic groups living in non-TOD, vehicle-dependent areas (Litman, 2024d).

> Introducing pedestrian zones across an area can reduce congestion on surrounding roadways and reduce both motorist and pedestrian injuries. The Broadway Boulevard Project in New York City introduced pedestrian zones across Times Square, Herald and Greely Squares, and Madison Square Park. These changes decreased congestion on most surrounding avenues and reduced traffic injuries by 63% and pedestrian injuries by 35% (C40, 2016).

RESILIENCE AND ADAPTATION

Adaptation strategies that support community density, like preservation of open green space, using greenways or other trails to mitigate flooding or heat impacts, or using multimodal hubs as evacuation points or heating/cooling centers for vulnerable populations help communities be more resilient to extreme events like floods (Davis et al., 2023).

RURAL COMMUNITIES

Although TOD is typically associated with high density, urban mixed-use (residential and commercial) development, and proximity to employment and daily destinations, it can also be applied to lower density settings and rural areas.

> An example is the historic town of Framingham, MA, which has plans to incorporate TOD in its downtown core due to changing market and resident demands. The historic town's growth in recent years has introduced a younger population to the downtown area, which has supported niche markets and a more urban lifestyle. In response, the town has submitted plans to the Massachusetts Department of Transportation and the Metropolitan Area Planning Council to create a more walkable and active, mixed-use development (City of Framingham, n.d.).

ECONOMIC GROWTH

There are significant economy-wide long-term cost savings associated with TOD and land use policies, resulting from increased property values for residents and businesses, easier travel, reduced pollution, and economic stabilization of neighborhoods (EPA, 2015).

By one estimate, a shift toward public and active transportation and denser urban development in the U.S. would save $13 trillion over the period 2023-2050, due to reduced costs for manufacturing, maintaining, fueling, and operating vehicles and building and maintaining infrastructure (Fulton and Reich, 2024).

TOD investments can generate large economic returns. The American Public Transit Association has found that investment in public transportation generates an estimated $5 in long-term annual economic returns, and every $1 billion invested in public transportation supports about 20,000 jobs (APTA, 2020).

TOD can support increased local foot traffic and public transit ridership, providing additional revenue to municipalities and transit agencies, as well as surrounding businesses (MAPC, 2017).

Transit infrastructure improvements can lead to higher local land values and spur more development. Land and property owners are often able to benefit from infrastructure investment in this way, and municipalities may be able to capture some of this value for residents through public-private partnerships, tax increment financing (TIF) districts, or other local measures (NASEM, 2020).

ACCESSIBILITY AND EQUITY

When TOD is implemented in previously segregated areas, it can improve transportation equity by connecting people to services and increasing access to opportunities previously not available due to transportation barriers (Holland, 2023).

"Transport poverty" occurs when people lack access to transportation options that are affordable and accessible. TOD increases access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities (IRPP, 2024).

Transportation costs can be reduced if affordable housing options are included in TOD. Residents of affordable housing can also have increased active transportation mobility if located near TOD (CAPCOA, 2021).

> During the planning phase of a new TOD, the planning board in Concord, MA negotiated for affordable housing units near the re-developed train station, allowing for residents of various incomes to live closer to transit (Holland, 2023).

TOD increases access to active and public transportation options, which are linked to decreased loneliness, increased access to family and friends, and greater levels of socialization Williams et al., 2021; Litman, 2024b).

Existing federal grant programs include opportunities to incentivize additional housing supply near transit to encourage more equitable development patterns. For example, Federal Transit Administration (FTA) includes land use and affordable housing as one of the criteria in the Capital Investment Grants program.

COST SAVINGS

Past suburban and exurban development resulted in families moving further and further from downtowns and urban centers to find affordable housing. In doing so, they often incur higher transportation costs associated with the location of that housing (Litman, 2024c).

Transportation is the second-largest household expense for low-income households, after housing (BTS, 2023).

In addition to the upfront costs of transportation, many of the costs associated with driving itself are not covered by user taxes. American households and the U.S. government combined currently pay $1,105 to $1,848 per household annually, which includes expenses such as road construction and maintenance, tax subsidies, and healthcare costs from car crashes and air pollution (Dutzik et al., 2015).

Shifting toward land use patterns that prioritize public transit and active transportation with TOD can reduce transportation costs by reducing the need for car ownership, maintenance, fuel, driving, and parking.

A study in California estimates, when controlling demographics, a household can save 18% of their annual transportation expenditures with TOD, which equates to around $1,232 per year. The study also shows TOD households in California own fewer vehicles (Dong, 2023).

AIR QUALITY AND HEALTH

TOD can reduce car reliance and associated vehicle emissions. Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways (Jbaily et al., 2022; EPA, 2014).

TOD residents who choose to integrate active transportation into daily routines can see improvements in physical well-being and stress reduction; for example, three hours of biking per week can reduce a person's risk of heart disease by 50% (Partlow, n.d.).

An additional health benefit from TOD relates to socialization. A 2023 advisory from the Surgeon General stated that the "mortality impact of being socially disconnected is similar to that caused by smoking up to 15 cigarettes a day" (HHS, 2023). A survey conducted by the City of Vancouver shows people are more likely to have a friendly social interaction when traveling by active transportation or transit than by private automobile (City of Vancouver, 2016).

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COST CONSIDERATIONS

While there are upfront housing development costs when implementing TOD, it can provide long term financial and economic development benefits. TODs and the associated transit infrastructure can increase property values and encourage further development, which can benefit property owners, local businesses, and municipalities (NASEM, 2020).

TOD is usually a long-term undertaking established at the city or town level. Local jurisdictions control multiple funding streams that can be used to support affordable and mixed-income housing in transit zones. TOD investments can concentrate business activity and tax bases, which generate new revenue that can be reinvested in communities. Value capture strategies include: property and sales taxes, real estate lease and sales revenues, farebox revenues, fees on everything from parking to business licenses, joint development, special assessment districts and public-private partnerships (Reconnecting America, 2014).

Tax Increment Financing (TIF) is a public financing method that local governments and transportation agencies may consider which captures a portion of additional property and sales tax revenues as a result of increased revenues from transit investments (NASEM, 2021).

> To learn more about how communities have encouraged TOD and capitalized on increased revenues, see this Reconnecting America resource developed in conjunction with the EPA and other partners.

Federal funding opportunities are available to support a variety of TOD projects. See more information below.

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

USDOT's **RAISE Discretionary Grant Program** includes funding for constructing surface transportation projects that will have a significant local or regional impact. The FY 2023 Notice of Funding Opportunity outlines the necessity of surface transportation components of transit-oriented development to advance goals of the program.

USDOT's **Transportation Infrastructure Finance and Innovation Act** and **Railroad Rehabilitation and Improvement Financing** programs, which provide low-interest financing for surface transportation projects, were expanded to include specific measures to better support TOD projects. Both programs may be used for economic development, including commercial and residential development, and RRIF may also fund public infrastructure and joint development.

FTA's **Pilot Program for TOD Planning** supports the expansion of more location-convenient and affordable housing near transit. Comprehensive planning funded through the program must examine ways to improve economic development and ridership, foster multimodal connectivity and accessibility, improve transit access for pedestrian and bicycle traffic, engage the private sector, identify infrastructure needs, and enable mixed-use development near transit stations.

U.S. Department of Housing and Urban Development (HUD)'s **Choice Neighborhoods Program** supports local investment and development through public and private funding. Communities can receive funding for planning to enable both public and private reinvestment in amenities that are important to residents, such as schools, businesses, and other community assets.

HUD's **Section 108 Loan Guarantee Program** provides Community Development Block Grant (CDBG) recipients with the ability to leverage their annual grant allocation to access low-cost, flexible financing for economic development, housing, public facility, and infrastructure projects. The program can fund TOD projects and related development efforts, either on its own or in combination with other economic development financing.

FTA's **Local Match Waver for Complete Streets** waives the non-federal match for the Metropolitan Planning Program and the State Planning and Research Program for Complete Streets planning activities. This waiver provides incentives for applicants to undertake complete streets infrastructure projects, which will increase convenience by diversifying the travel modes individuals can choose.

HUD's **Exploring Office to Residential Conversions** grant program provides funding for residential conversion activities, which can be relevant for TOD.

COMPLEMENTARY STRATEGIES

TOD can encourage active transportation by creating compact, mixed-use neighborhoods with pedestrian-friendly streetscapes and bike infrastructure. Active transportation infrastructure can enhance the accessibility and attractiveness of TOD by providing residents and visitors with safe and convenient options to access transit hubs and navigate the surrounding area. TOD and active transportation infrastructure work together to promote sustainable mobility and reduce GHG emissions.

Coordinated transportation planning, or planning across sectors (i.e., transportation and housing), jurisdictions (i.e., neighboring municipalities), and levels of government (i.e., municipal, county, and state), complements TOD by ensuring that these developments meet a range of community needs. For example, when coordinated transportation planning for TOD involves the housing sector, it can help ensure that there is a range of affordable housing options to meet diverse needs and income levels. Conversely, TOD can help achieve coordinated transportation goals, such as those related to affordable housing, access to jobs, and reducing GHG emissions.

Creating denser, mixed-use developments can increase demand for bus rapid transit and other public transit systems. Combining TOD with investments in BRT can reduce distances between common destinations and lower GHG emissions.

Free and reduced transit fare strategies further incentivize people to use public transportation, increasing ridership and supporting the viability of TOD. Free and reduced transit fare strategies can also help mitigate transportation costs, making it more attractive to live in TOD areas and reduce barriers to accessing employment, education, and essential services. TOD and free and reduced transit fare strategies work together to promote equitable access to transportation while reducing GHG emissions.

TOD can increase the demand for public transit services by creating dense, mixed-use neighborhoods where residents have easy access to transit options. Public transit expansion can support TOD by providing reliable and convenient transportation access to and from these developments, thereby increasing their attractiveness and viability. Overall, combining TOD with public transit expansion can lead to lower GHG emissions, and more vibrant, livable communities.

Integrated transit systems make it easier for residents of transit-oriented developments to travel within the community and beyond, enhancing attractiveness of these developments. Conversely, transit-oriented development can increase ridership of public transportation, making the case for further investment in transit integration to support growing demand.

TOD facilitates trip planning by providing easy access to transit options. Trip planning and modal integration can be attractive to TOD residents and visitors, allowing them to easily plan trips using digital, real-time trip planning tools and apps, while knowing that stations are conveniently located and well-connected to their destinations.

Zoning reform can facilitate the development of TOD projects by allowing for higher densities, reduced parking requirements, and streamlined approval processes.

View All Strategies

CASE STUDIES

BAY AREA RAPID TRANSIT TOD

In 2018, California passed the AB 2923 for the zoning of Bay Area Rapid Transit (BART) properties in Alameda, Contra Costa, and San Francisco Counties located within half a mile of transit stations. AB 2923 established baseline zoning standards and allowed BART to work with local jurisdictions to determine more stringent land use standards to enable TOD. The State Legislature developed this unique law as a way to address the high cost of housing and lack of affordable housing. BART's TOD program aims to encourage livable communities; increase ridership and housing affordability; and provide sustainable housing choices; among others.

VALLEY EXTENSION PROGRAM - SILICON VALLEY, CA

The Valley Transit Authority (VTA) has completed phase 1 of a transit corridor project to significantly expand public transit and regional rail service for 1.7 million county residents. The project will be implemented in two phases and is expected to be completed in 2040. The VTA aims to create multiple transit-oriented communities in Silicon Valley, offering multimodal transportation connectivity, affordable housing options, and parking requirements, in addition to roadway, utility, and environmental improvements.

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CONCORD COMMONS MIXED-USE DEVELOPMENT - CONCORD, MA

The Concord Commons is a mixed-use development in the small town of Concord, MA. The development is centered around a commuter rail station with a historic station building built in the 1800s. Sections of the parking lot area were converted to a landscaped garden and pedestrian walkway linking to the town center. The Concord Commons is an example of a small-town transit-oriented project providing walkable links between transit, housing, and daily destinations.

(Source: Littleton, MA)

ROSSLYN-BALLSTON CORRIDOR - ARLINGTON COUNTY, VA

Arlington County, VA implemented transit-oriented policies to increase development density along transit lines. Despite population growth at 1% per year, VMT has not increased, equating to 20%-30% VMT per person reduction from 1980 to 2005. Transit and active transportation modes of travel make up 47% of the commute, compared to a regional average of 29%. Compared to a regional average of 4%, 12% of households in Arlington County do not own a car.

IMPLEMENTING TOD: **WHAT TO READ NEXT**

Technical assistance, such as through FHWA's National Highway Institute's "Integrating Transportation and Land Use" course, can help transit agencies and local governments implement TOD projects. The course focuses on augmenting the resources available to communities and providing expertise in navigating grant programs to integrate transit and development.

The Institute for Transportation and Development Policy has a range of resources on TOD, including a TOD Standard Guide to understand, measure, and evaluate the key principles in urban spaces.

C40 Knowledge Hub provides a TOD implementation framework with a range of resources and case studies.

The Global Platform for Sustainable Cities provides a comprehensive toolkit with a step by step process for implementing different phases of TOD, as well as a focus on lower-middle income contexts.

HOW TO IMPLEMENT

Cities can set TOD targets to inform developers and residents of development visions and planning (C40, 2019).

New York City set a goal of 95% of new housing to be built within a half mile of transit stations. Los Angeles set TOD targets for new housing units within 1,500 feet of transit stations: 17,000 units by 2017 (met), 57% by 2025, and 65% by 2035. Portland, OR has set TOD goals encourage mode choice to active transportation modes and develop 20-minute-neighborhoods. In 2012, 45% of Portland residents lived in a "complete neighborhood" and the city aims to reach 80% by 2035 (C40, 2019).

TOD districts can benefit from Station Area Plans (SAP) that provide a development vision specific to the individual transit station. For more information about station area planning, see: TOD 202: Station Area Planning, developed by Reconnecting America and the Center for Transit-Oriented Development.

RESOURCES

GENERAL RESOURCES

EPA Smart Location Mapping tools: The Environmental Protection Agency (EPA) provides tools that can compare the accessibility of neighborhoods via public transit service across metropolitan regions in the United States. The tools can be used to evaluate current transit-oriented development projects or scope future projects and prioritize location-efficient investments. The tools are:

- Smart Location Database: This tool is a geographic data resource for measuring location efficiency across the U.S.
- Access to Jobs and Workers Via Transit Tool: This tool is a geospatial data resource and web mapping tool summarizing accessibility of jobs by workers, households, and population in neighborhoods via public transit.
- National Walkability Index: This tool is a nationwide geographic data resource ranking the walkability of census block groups.

FHWA National Highway Institute Integrating Transportation and Land Use course: The course can help transit agencies and local governments implement TOD projects. The course focuses on augmenting the resources available to communities and providing expertise in navigating grant programs to integrate transit and development.

Global Platform for Sustainable Cities Transit-Oriented Development Community of Practice : This resource includes a step by step process for implementing different phases of TOD, as well as a focus on lower-middle income contexts.

C40 Knowledge Hub How to Implement Transit-Oriented Development: This is a TOD implementation framework with a range of resources and case studies.

EPA TOD Infrastructure Finance Guide. In collaboration with four transit agencies, EPA developed a set of case studies that describe how the range of public and private financing models can be combined to support the essential infrastructure improvements that are often needed to accommodate TOD.

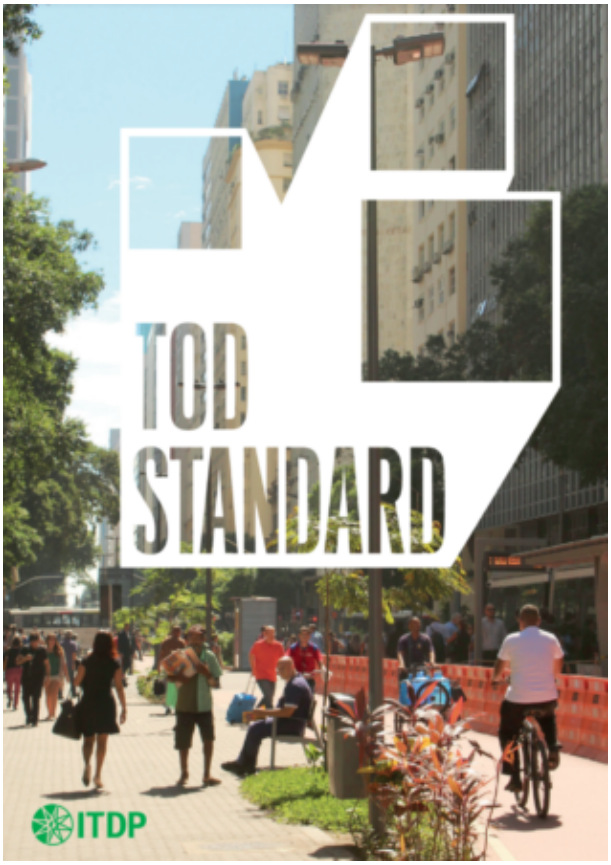
FTA Interim Asset Disposition Guidance. FTA has put forth interim guidance on asset disposition for federal assistance recipients, which authorizes transfer of assets to a local governmental authority, non-profit organization, or other third- party entity if, among other factors, it will be used for TOD and includes affordable housing.

FTA Joint Development Guidance: This FTA guidance supports flexibility for transit agencies to pursue joint development projects, with a goal of

creating more value for both transit systems and surrounding communities.

The White House Commercial to Residential Conversations: A Guidebook to Available Federal Resources: The guidebook presents an overview of the federal programs, loans, grants, guarantees, and tax incentives available for commercial to residential conversions. This list includes resources relevant for transit-oriented development.

Institute for Transportation and Development Policy TOD Standard Guide: The guide helps practitioners understand, measure, and evaluate the key TOD principles in urban spaces.



(Source: ITDP, 2017)

TOOLKITS AND MODELING APPROACHES

National Level

FHWA Performance-Based Approach to Addressing Greenhouse Gas Emissions through Transportation Planning (2013): This resource helps State DOTs and MPOs integrate GHG analysis into performance-based planning and programming. The resources also provides case studies.

FTA Transit Greenhouse Gas Emissions Estimator: The estimator is a spreadsheet-based tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operation, and maintenance phases of a project across select transit modes. Users input general information about a project, and the Estimator calculates annual GHG emissions generated in each phase.

Infrastructure Carbon Estimator (ICE) – ICE is a spreadsheet tool that estimates the lifecycle energy and GHG emissions from the construction and maintenance of transportation facilities. ICE is intended to inform planning and other pre-engineering analysis such as those conducted during the NEPA process.

Travel demand model + EPA Motor Vehicle Emission Simulator (MOVES): The MOVES model provides tailpipe emission rates and mobile-source inventories.

Transportation Pooled Fund VisionEval Project and Associated Tools (i.e., Energy Emissions Reduction and Policy Analysis Tool; EERPAT): These tools are designed to evaluate many alternative futures and policies to help state and metropolitan area governments address pressing issues, despite uncertainty.

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

The Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

Department of Energy (DOE) Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics, for insight on the interconnected impacts between transportation and land use decisions.

DOE and National Renewal Energy Laboratory (NREL) Mobility Energy Productivity (MEP): This metric is used to measure the existing and potential impact of changes in mobility options across transportation modes at the community or regional level. The MEP metric takes into account travel time, energy, and affordability. DOE's Lawrence Berkely National Laboratory (LBNL) developed the Individual Experienced Utility-Based Synthesis (INEXUS). INEXUS is a suite of accessibility metrics that measure agent-trip level accessibility. These metrics can be used to identify and measure individual travelers who benefit from improved mobility under different simulation scenarios. Tools such as these can be used to design improved operational efficiency in existing and future transportation systems.

State Level

California Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: This handbook provides GHG calculation methods and variables to consider for project level TOD. The handbook also offers quantitative measures of co-benefits.

California Emissions Estimator Model (CalEEMod): CalEEMod is a statewide land use emissions computer model designed to provide a uniform platform for government agencies, land use planners, and environmental professionals to quantify potential criteria pollutant and greenhouse gas (GHG) emissions associated with both construction and operations from a variety of land use projects.

Fehr & Peers TDM+ (Beta): This is a VMT calculation tool designed for the State of California, which allows users to calculate the impacts of potential VMT reduction strategies, using various data inputs.

Local Level

Chicago and San Francisco: Center for Neighborhood Technology ETOD Impact Calculator: This calculator provides benefits of equitable TOD projects, including number of residents housed, residential buying power, on-site jobs, tax revenue, GHG, among others.

Washington State Tools for Estimating VMT Reductions from Built Environment Changes: This resource provides a list of tools to estimate GHG based on land use and transportation inputs. Applications can range from State, urban, and local community scales.

WORKING WITH COMMUNITIES

Institute for Transportation and Development Policy: This website provides information on TOD, a standard policy brief with standardize principles of TOD, and a scorecard to evaluate if TOD developments meet the outlined principles.

Center for Neighborhood Technology (CNT): CNT offers resources on advocating for TOD at the community level.

Planetizen: This website provides a course in equitable transit-oriented development, prioritizing inclusive community development. The course is open to the public.

RURAL SPECIFIC

FTA National Rural Transit Assistance Program (RTAP): This FTA program provides technical resources, toolkits, training, webinars, a resource library, news updates, and information on Tribal transit and State RTAP programs.

AARP Livable Communities Transportation and Mobility: This website includes resources such as policy briefs and a rural transportation toolkit for rural communities on the topics of livability, funding opportunities, health care, and transportation options available in rural areas.

Community Transportation Association for America Transit Planning 4 All: This program, in partnership with several organizations, supports older adults and people with disabilities in getting involved in coordinated transportation system development. The members are involved in surveys, research activities, grants, and creating a knowledge sharing network.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

TRANSIT SYSTEM INTEGRATION

Transit system integration seamlessly links transit and multimodal networks, creating a convenient, safe, accessible, and efficient transportation system, while reducing reliance on vehicle travel.

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OVERVIEW

Best Suited for:
Long Term
Urban, Suburban

Transit system integration offers efficient services to users by **linking infrastructure, operators, and transport modes**. Better integrated transport systems can make public transit, walking, and biking more accessible and user-friendly and reduce dependence on a household vehicle.

Public transportation systems can be integrated in a number of ways: **physical integration, institutional integration, integrated information, integrated networks, and integrated fares**.

Physical integration positions infrastructure closer together to facilitate transfers and improve accessibility of the transit system. Extending the reach of the transit system with complementary infrastructures increases access to public transportation for trips that might otherwise be made by car or not made at all. Physical integration can also include signage and physical displays providing information of an integrated transit system.

Institutional integration involves strategically coordinating efforts across an agency, or across agencies for seamless delivery of transit system integration.

Did you know?

A bus can, on average, replace around 5.83 cars for the efficient use of road space, along with other forms of public transit (Swamy, 2023).

Multiple types of transit services, such as bus, rail, ferries, paratransit, and shuttle agencies, can work together to share control functions for greater efficiency.

Integrated information allows users to make efficient and convenient travel decisions. Information can include route details, stops and stations, services available, ticketing, and wayfinding. General Transit Feed Specification (GTFS) is a standard form of data sharing used across transit systems allowing information to be integrated easily across various platforms such as Google Maps.

Integrated route schedules can enhance opportunities of transfer in routes during the same operation hours and minimize transfer time for highly used routes.

Integrated networks include connected routes and services across modes of travel to ensure transferability and accessibility. Transit network planning can support integrated networks through strategic planning on network design, tactical planning on frequency

setting and timetables, and operational planning through scheduling and maintenance.

Integrated fares and equitable fares across the transit system can include fares with no transfer fees, penalties, or purchase of separate tickets for different travel modes. These fares are meant to be convenient and affordable, encouraging greater usage of public transit.

Transit system integration can also include **fare capping**, whereby customers can pay as they go and have fares capped on a daily or monthly basis such that they do not exceed the price of a comparable daily or monthly pass across different transit modes. This removes financial barriers for customers who may not be able to pay for a monthly pass upfront and increases convenience for customers by providing them the best fare without needing to determine whether to purchase a pass upfront.

The various network elements of transit system integration can improve convenience and efficiency of travel, encouraging travelers to use a multimodal transportation system as an alternative to single occupancy vehicles. **Fewer vehicles on the road reduces vehicle traffic congestion, fuel consumption, and associated GHG emissions.**

Examples of Transit System Integration Strategies

- **New technology platforms** that provide real-time information to riders via apps, websites, or physical displays at stops or onboard vehicles.
- **Addition of last mile connectivity solutions** at transit stations, such as micro transit and shared mobility to improve access to final destinations for transit riders.
- **Integration of transit fare systems** so that one payment method can be used to ride multiple modes of transit from different providers.
- **Operational integration** across routes, modes, and operators, which makes transfers easier and encourages additional ridership.
- **Transit fare caps and transfers** to make longer or more frequent trips by transit more affordable.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

CLIMATE BENEFITS OF PUBLIC TRANSIT

Public transportation is more energy efficient than single-occupancy vehicles. Passenger vehicles produce on average 0.47 lbs. of CO_2 per passenger-mile compared to 0.17 lbs. of CO_2 per passenger-mile emitted from rail transit and 0.39 lbs. of CO_2 per passenger-mile from buses (Congressional Budget Office, 2022).

In 2018, the U.S. saved an estimated 63 million metric tons of CO_2 equivalent emissions through public transit and avoided 148 billion miles of personal vehicle travel, or 5% of the 3 trillion total U.S. vehicle miles that year (NASEM, 2021).

Improvements to public transit infrastructure and operations can encourage transit ridership and serve as a low carbon alternative to highway expansion projects. Improving intercity rail networks and upgrading to high-speed rail networks can also promote less carbon intensive modes of long-distance travel. A Transit Cooperative Research Program report found that increased transit ridership through an existing service, or restructured service with a focus on more frequent routes, significantly reduced GHG emissions (Filosa et al., 2017).

INTEGRATED TRANSIT SYSTEMS FACILITATE MODE CHOICE AND REDUCE PARKING

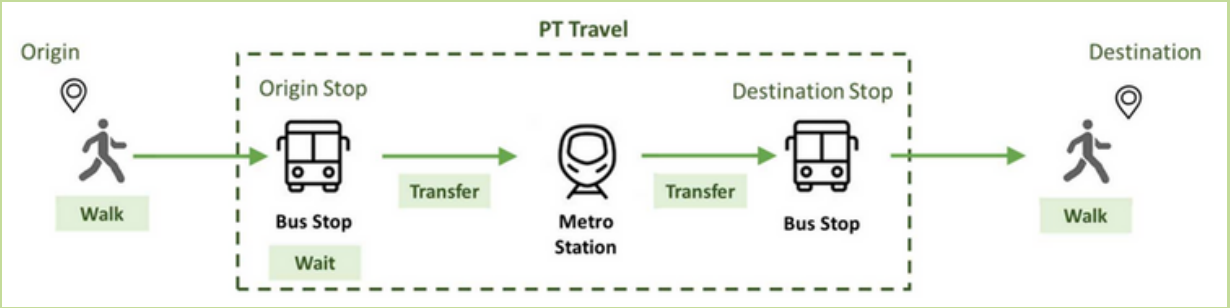
Enhanced transit services can decrease the vehicle miles traveled (VMT) and associated greenhouse gas (GHG) emissions by making public transportation a more appealing and convenient option for travelers over household cars (Swamy, 2023). A key component of transit enhancements is integration of routes and fares, multimodal transportation options, and additional services such as traveler information.

A study of the San Francisco Bay Area Rapid Transit found that integrating an app-based carpool transit access program encouraged 64% of travelers to choose transit over single vehicle travel. The study also found that the carpool trips taken reduced VMT by 44% (Martin et al., 2020).

Integrated public transit can also optimize urban street space by reducing the need for parking for vehicles and passenger vehicle trips, which are space inefficient (Swamy, 2023).

Transit integration can be relevant choice for suburban communities. Suburban transit systems can be networked via local area circulators, shuttle links, subscription buses, and vanpools, complementing and connecting to existing transit networks in urban areas to provide alternative options to single vehicle travel (Santa Maria et al., 2005).

Example of a singular trip within an integrated multimodal transit system



Source: Swamy, 2023

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Integrated transit systems can increase reliability and road safety, as public transport has fewer on-street fatalities than passenger vehicles. Estimates indicate the fatality rate of a bus is 1/25th of that of a car (Swamy, 2023). Increasing the number of trips taken by transit will therefore have a positive impact on the overall safety of the transportation system. In the case of NYCDOT/MAT M15 select bus service (SBS) route, bicycling increased 18% to 177% due to bicycle safety improvements implemented in conjunction with SBS infrastructure (Beaton et al., 2012).

An example of the federal government's commitment to increase the safety of our infrastructure can be found here: Department of Transportation Fiscal Year 2022-2026 Strategic Plan

ECONOMIC GROWTH

Transit is a $79 billion industry and employs more than 370,000 people across more than 1,000 private companies and 4,000 transit operators. According to the American Public Transportation Association's research, every $1 invested in transit generates $5 in economic returns.

Every $1 billion invested in public transportation supports and creates approximately 50,000 jobs (APTA, 2020).

COST SAVINGS

Integrated public transit can lead to reduced travel time and costs for users, as well as increased public transit ridership and revenues for operators (Shen & Wang, 2022; Swamy, 2023). A study of the integrated suburban transit system in Contra Costa County, California found that improved operation efficiency and connectivity reduced bus to bus passenger wait time by an average of 28.3 minutes and transit to bus wait time by 30.7 minutes (Meng et al., 2018).

Cost saving benefits for transit integration depend on the agencies and the contexts where the integration occurs. Some agencies may see cost savings depending on existing infrastructure and the range of integration, planning, number of projects, size of agency, and financial commitment available.

Specific analyses to determine cost effectiveness are necessary (Goldman, et al., 2014). Agencies can coordinate resources to integrate multiple systems, resulting in overall cost savings. Splitting costs amongst agencies for a project or service can also reduce the burden on any one agency. Multiple agencies purchasing equipment jointly can result in discounts through bulk purchasing to further reduce costs (Goldman, et al., 2014).

Revenues in an integrated system can be coordinated through an integrated electronic fare system, which can charge passengers by distance or time, regardless of the number of transfers. This allows different public transport operators to divide their revenues equally according to the distance traveled on each transport type (Zimmerman & Fang, 2015).

Passenger costs savings from integrated transit can be significant. A study of the Puget Sound region in Seattle, Washington found that the integration of transportation networking companies (TNCs) with public transit resulted in significant cost savings for 39% of travelers (Martin et al., 2022).

ACCESSIBILITY AND EQUITY

Integrated public transport systems can support access to jobs and services, as well as sustainable financing for infrastructure and operations (Integrated Transport, 2021).

Fare integration can make riding public transportation across modes easy, accessible, equitable, and environmentally friendly (Swamy, 2023).

> The San Francisco Bay Area has an integrated fare system vision to provide users with affordable access to opportunities without reliance on driving. The fare system is discounted for a range of riders including children under 12 years of age, seniors over the age of 65, youth, students, persons with disabilities, and low-income households. The system also offers daily, weekly, and monthly passes for low-income riders with a cap on rides. After a certain number of rides, if a cap is reached, the rest of the daily, weekly, or monthly rides are free (Seamless Bay Area's Vision for Integrated Fare Vision, n.d.).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

The Utah Transit Authority System in Salt Lake City implemented a system to **coordinate passenger transfers between its light rail trains and buses** at 20 rail stations. The system assisted bus operators, radio controllers, and customer service personnel to improve customer service by reducing the chances of missed connections and connecting heavily used services with less frequently used services. The software integrating the systems and data for this effort cost $305,000 (Hodges & Hess, 2003).

The Montachusett Area Regional Transportation Authority (MART) put forward a project to develop and design a system and **travel management coordination cente**r using intelligent transportation system (ITS) capabilities. MART provides transportation through fixed-route and paratransit operations in the north central region of Massachusetts. The purpose was to design a system that managed and coordinated the region's transportation services as well as facilitate the exchange of data between users and transit providers. The design of the project cost $372,000, with implementation and design costs totaling $3,942,000.

Operational costs were estimated at around $100,000-$350,000 per year (Montachusett Regional Transit Authority, 2012).

Real-time transit information can represent a means for improving the integration of transit services. A review of King County Metro's digital sign installation program found that costs ranged between $3,590 and $17,810 depending on the size and power source (Fesler, 2021).

Mobility hubs are a technique that some cities have deployed as a means for improving last-mile connections to transit. Columbus, Ohio spent approximately $1,330,000 on deploying six mobility hubs in underserved communities. These installations included bike sharing stations and other amenities that were intended to improve last-mile connections to transit and other local destinations (City of Columbus Program, 2023).

Transit system integration can be incorporated into multimodal trip planning systems.

A Chicago Regional Transportation Authority (RTA) study found that the implementation of a trip planning system in the region could cost between **$138,000 to $4,000,000**.

The San Francisco MTC estimated the costs of its system implementation to be around **$2 million**.

The data development process can play a major role in the extent of the costs that an agency faces, and agencies that have existing standardized transit data feeds will generally be able to implement a trip planning platform at a much lower cost. Transportation agencies can form partnerships with other mobility providers to share data across linked trips (APTA, 2016).

Portland's TriMet used an open source data format for their trip planning application, requiring only $138,000 in initial investment costs (Biernbaum et al., 2011). With General Transit Feed Specification (GTFS) data becoming more common with transit agencies, it is likely that the implementation costs of trip planning tools will decrease going forward.

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

FHWA's **Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN)** grant programs support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance transportation system efficiency include implementing technology to enhance high occupancy vehicle toll lanes, integration of transportation service payment systems, and implanting advanced mobility access and on-demand transportation service technologies.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART)** grant program funds demonstration projects focused on advanced smart community technologies and systems that improve transportation efficiency and safety. Eligible projects include connected vehicles, aviation innovation, smart grid, and traffic signal innovation.

FHWA's **Exploratory Advanced Research (EAR) Program** is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

USDOT's **Flexible Funding for Transit and Transit Access** program reduces emissions through transit investment. Transferring, or flexing, funds from Federal Highway programs to the Federal Transit program facilitates federal investments at the local level for measures that improve access, particularly for underserved groups.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

Reduced fares for seniors, people with disabilities, and Medicare cardholders. Under 49 U.S.C. Section 5307, federally subsidized transit providers may not charge more than half of the peak fare for fixed route transit during off-peak hours for seniors, people with disabilities, and Medicare cardholders. This policy increases access to transit for these major swaths of the population, while also assisting some of the people who are most likely to benefit from reduced financial burden to use transit.

COMPLEMENTARY STRATEGIES

Coordinated transportation planning can lead to transit system integration as one outcome of better coordinated land use between housing and transportation and cross-jurisdictional public transportation system alignment.

Expanding transit can create additional opportunities for integration with expanded routes or more frequent connections make transfers more convenient and accessible.

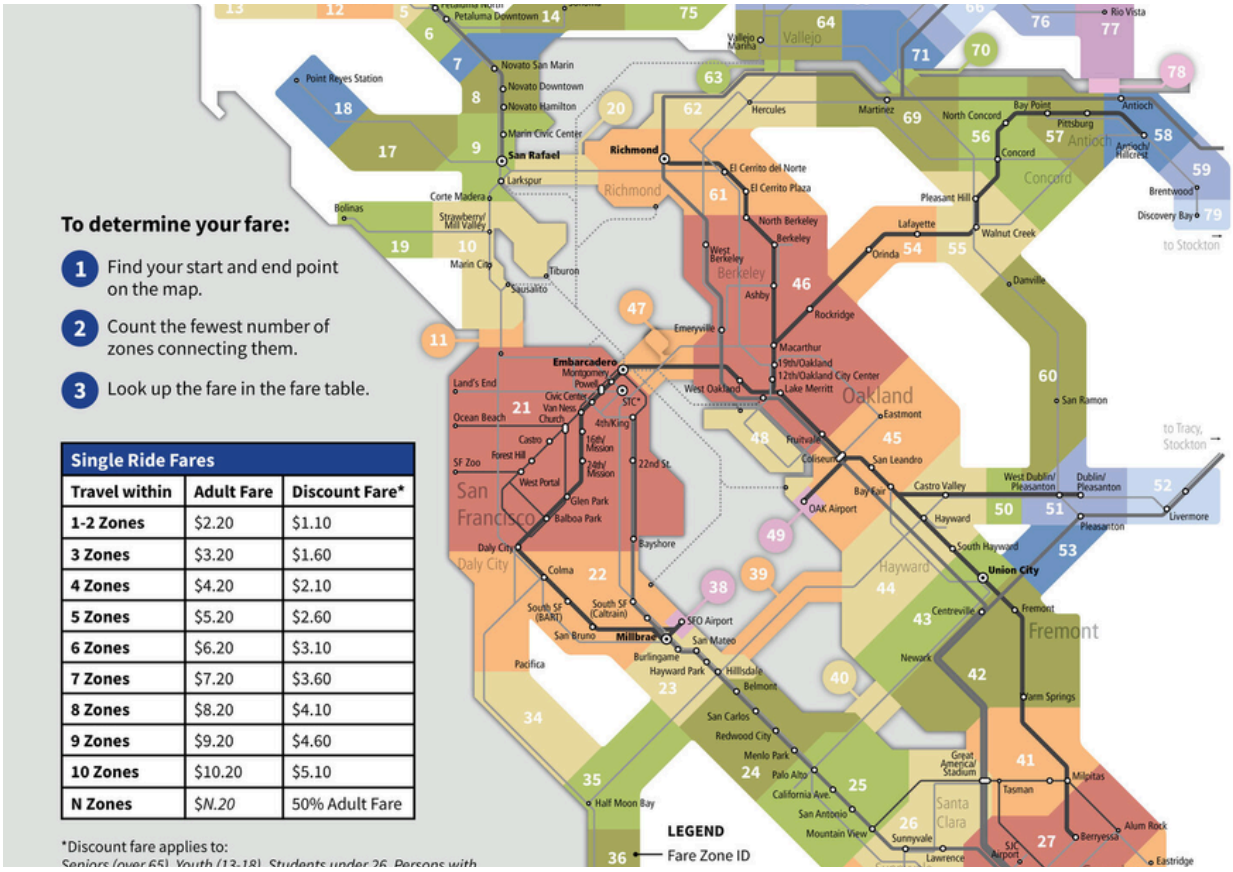
Shared micromobility can enhance first- and last-mile transportation access to public transit and serve as a physical integration at a bus stop or rail station.

Transit-oriented development can increase ridership of public transportation, supporting further investment in transit system integration to support growing demand.

By integrating transit and providing travelers with the trip planning and modal integration tools they need to plan their journeys effectively, communities can encourage more people to use public transportation.

CASE STUDIES

INTEGRATED TRANSIT, BAY AREA, CA:



Source: Seamless Bay Area

The Bay Area's Integrated Transit Fare Vision aims to be an equitable, affordable, rider-focused transit fare system. The system is still under development, with a vision to allow users to select the fastest service to reach destinations with unlimited transfers for the price of a local fare. For example, a user would pay the fare of one bus trip for the fastest route to a destination involving two stops on the train and a bus transfer. A rider would not have to choose between using only a bus or a train due to price differences. All routes, regardless of number of transfers, are the same low fare. A standard discount of 50% for a range of underserved and vulnerable populations is also available. To implement this system, the Bay Area has a developed range of potential tools, including a fare calculator, route planning, and a vision map. Funding and networked operations management system are next steps.

ORCA SMART CARD, WASHINGTON:

The Puget Sound Region of Washington introduced the ORCA card, a contactless smart card for the public transit system in the Seattle metro area. The smart card serves the transit system, bus agencies, ferries, and water taxis. The card was launched through the coordination of multiple transit agencies and offers free transfers within a two-hour window across modes of transportation. A website and app are available to help users manage accounts, purchase mobile tickets, add value to accounts, and keep the card secure.

Source: My Orca

Source: SEPTA

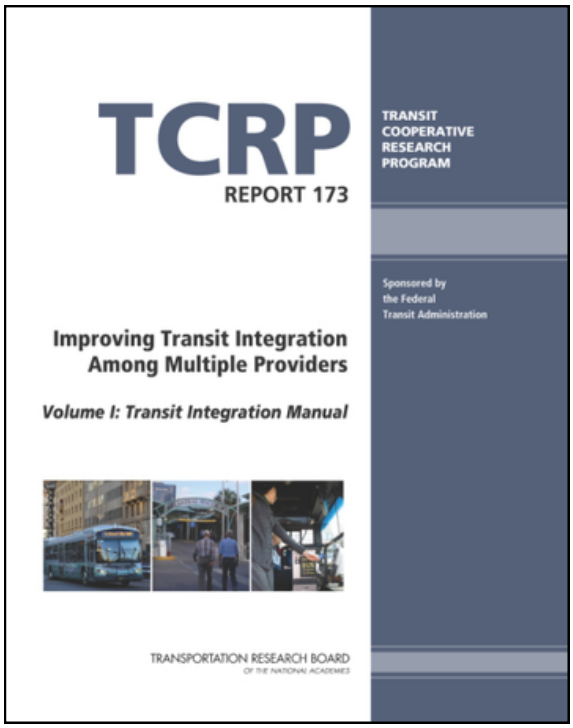
SEPTA, PHILADELPHIA:

The Southeastern Pennsylvania Transportation Authority (SEPTA) is a transit system supporting five counties in the greater Philadelphia area and extends transit services to New Jersey and Delaware. The system integrates regional rail, bus, trolley, subway, and high-speed line modes of transportation. Through the integrated system, SEPTA is able to provide trip planning services, transfer without pay options, a reloadable smart card for seamless travel, and other connected services.

IMPLEMENTING TRANSIT SYSTEM INTEGRATION: **WHAT TO READ NEXT**

The Transit Cooperative Research Program Transit Integration Manual provides guidance on the various integration-related topics that an agency can explore, ranging from passenger information systems to operational aspects such as integrated fare systems. The manual also offers a number of examples on how certain transit providers have approached the topic of integration.

The Intelligent Transportation Systems Joint Program Office (JPO) website contains a number of case studies relevant to the implementation of transit integration strategies. These include topics such as first/last mile connections, shared mobility services, and microtransit, with a focus on the costs of these programs, and measurable benefits (such as increased ridership, user satisfaction, and accessibility).



Source: Goldman et al., 2014

Last mile connections are an important component of a transit integration strategy, as they improve access to transit services in lower density or underserved areas. The American Public Transit Association (APTA) has **examples** of strategies that various cities and transit agencies have used to approach last mile transit connections, such as micro transit and shared mobility services. APTA also produced a guide on best practices for integrating bicycles with transit services.

RESOURCES

GENERAL RESOURCES

United Nations ESCAP Guidebook on Integrated Public Transport System: This global guidebook provides the elements of integrated public transport systems, approaches and methodologies for urban and transport plans, application of various public transport modes, an integrated operations strategy, application of digital technologies, formulation of fare policies and integration, and the digital transformation of public transport.

National level

Intelligent Transportation Systems Joint Program Office (JPO) website: This website contains a number of case studies relevant to the implementation of transit integration strategies. These include topics such as first/last mile connections, shared mobility services, and microtransit, with a focus on the costs of these programs, and measurable benefits (such as increased ridership, user satisfaction, and accessibility).

American Public Transit Association (APTA): This resource has examples of strategies that various cities and transit agencies have used to approach last mile transit connections, such as micro transit and shared mobility services. APTA also produced a guide on best practices for integrating bicycles with transit services.

Transit Cooperative Research Program's Improving Transit Integration Among Multiple Providers Volume 1: Transit Integration Manual: This resource provides guidelines, resources, and examples to transit agencies in the evaluation, planning, and implementation of transit service integration.

State level

San Francisco Bay Area Fare Coordination and Integration Study: This study provides an example of efforts to integrate transit fares in the Bay Area.

Puget Sound Transit Regional Transit Integration: This resource is a view into the Seattle region's transit integration activities, lessons learned, progress, and ways forward. The report can be an applicable resource for other agencies interested in regional integration.

TOOLKITS AND MODELLING APPROACHES

National Level

EPA Motor Vehicle Emission Simulator (MOVES): MOVES provides tailpipe emission rates and mobile-source inventories and can be used to estimate transit emissions.

FTA Transit Greenhouse Gas Emissions Estimator: The estimator is a spreadsheet-based tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operation, and maintenance phases of a project across select transit modes. Users input general information about a project, and the Estimator calculates annual GHG emissions generated in each phase.

Infrastructure Carbon Estimator (ICE): ICE is a spreadsheet tool that estimates the lifecycle energy and GHG emissions from the construction and maintenance of transportation facilities. ICE is intended to inform planning and other pre-engineering analysis such as those conducted during the NEPA process.

Transportation Pooled Fund VisionEval project and associated tools (i.e., Energy Emissions Reduction and Policy Analysis Tool; EERPAT): These tools are designed to evaluate many alternative futures and policies to help state and metropolitan area governments address pressing issues, despite uncertainty.

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

The Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

DOE Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics,

for insight on the interconnected impacts between transportation and land use decisions.

DOE and National Renewal Energy Laboratory (NREL) Mobility Energy Productivity (MEP): This metric is used to measure the existing and potential impact of changes in mobility options across transportation modes at the community or regional level. The MEP metric takes into account travel time, energy, and affordability. DOE's Lawrence Berkeley National Laboratory (LBNL) developed the Individual Experienced Utility-Based Synthesis (INEXUS). INEXUS is a suite of accessibility metrics that measure agent-trip level accessibility. These metrics can be used to identify and measure individual travelers who benefit from improved mobility under different simulation scenarios. Tools such as these can be used to design improved operational efficiency in existing and future transportation systems.

State Level

Washington State Tools for Estimating VMT Reductions from Built Environment Changes: This resource provides a list of tools to estimate VMT based on land use and transportation inputs. Applications can range from State, urban, and local community scales.

Fehr & Peers TDM+ (Beta): This is a VMT calculation tool designed for the State of California, which allows users to calculate the impacts of potential VMT reduction strategies, using various data inputs.

Rural Specific

FTA National Rural Transit Assistance Program (RTAP): This FTA program provides technical resources, toolkits, training, webinars, a resource library, news updates, and information on Tribal transit and State RTAP programs.

AARP Livable Communities Transportation and Mobility: This website includes resources such as policy briefs and a rural transportation toolkit for rural communities on the topics of livability, funding opportunities, health care, and transportation options available in rural areas.

Community Transportation Association for America Transit Planning 4 All: This program, in partnership with several organizations, supports older adults and people with disabilities in getting involved in coordinated transportation system development. The members are involved in surveys, research activities, grants, and creating a knowledge sharing network.

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U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

TRIP PLANNING TOOLS AND MODAL INTEGRATION

By integrating travel mode information in real-time, trip planning tools facilitate faster, more connected trips and promote multimodal transport options, providing users with greater convenience and cost savings and reducing vehicle congestion and emissions.

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OVERVIEW

Best Suited for:
Long Term
Urban, Suburban, Rural & Tribal

Trip planning tools can provide a range of information for multimodal travelers, such as maps, routes, schedules, fares, and real-time arrival and departure information through websites, mobile phones, and other handheld devices with GPS location capabilities. These tools can also guide users toward time-saving or efficient routes and provide additional services such as payment of transit and taxi fares, bikes rentals, and parking.

(Source: CalITP)

In cities designed with multimodal options of travel, including walking, biking, rolling, and transit, **trip planning tools can plan routes integrating multiple modes to reach destinations according to preferences, accessibility needs, timing, and cost-efficiency.** For example, a trip planning mobile app can guide a traveler to their destination, which could include walking to an e-bike station, riding the e-bike to a bus stop, waiting in a safe and covered shelter, and reaching the destination by bus in time. Trip planning tools can also facilitate awareness of and access to multimodal transportation options.

Did you know?

The first transit agency to implement a multimodal trip planner with integrated walking, cycling, and transit journeys is in Portland, Oregon. The Trimet Trip Planner includes features such as an elevation chart for cycling preferences and locations of carshare options.

Trip planning and modal integration tools increasingly rely on vehicle-to-infrastructure (V2I) technologies for real-time, multi-modal data. V2I is a type of intelligent transportation system (ITS) that can wirelessly provide information to drivers related to safety, mobility, or environmental conditions. V2I technologies use vehicle-generated traffic data to produce information, enabling communication between road systems and vehicles. V2I-based tools allow for more precise and convenient multi-modal planning, reducing traveler reliance on single occupancy vehicles and other high GHG emitting transportation sources.

See the U.S. Department of Transportation's ITS Joint Program Office website for more information about recent V2I deployments, including trip planning tools.

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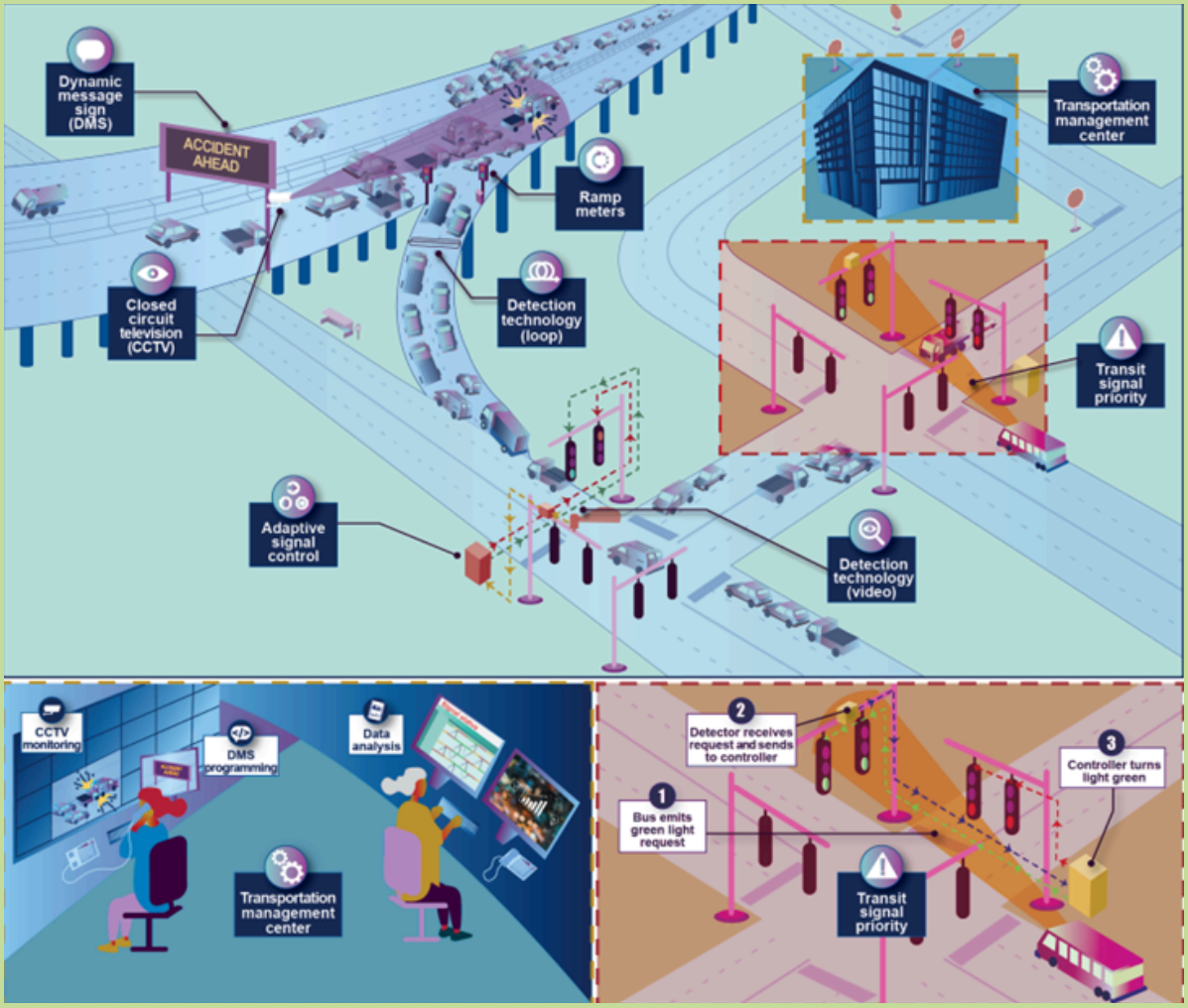
Connected Vehicles and V2I:

V2I technologies support information exchange between vehicles and roadway infrastructure (GAO, 2023). They can provide routing and passenger information from vehicles to agencies and vice versa for all road users related to safety issues and traffic information (Lee et al., 2016). V2I can be incorporated in transit apps or other trip planning tools to enhance routing capabilities and ensure the most up-to-date information is available.



The image is an example of ITS in action in a metropolitan area to improve transportation management. The integrated system includes the technologies in place as well as a management center for monitoring, programming, and data analysis. Transit signal priority technology is featured, in which (1) a bus emits a green light (2) the light is detected and sent to a traffic signal controller and (3) the traffic signal controller sends a command to turn the light green (Source: GAO, 2023).

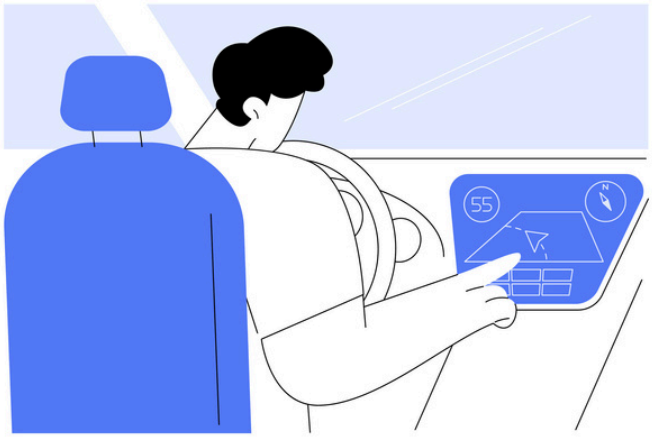
GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

GHG EMISSIONS BENEFITS OF TRIP PLANNING TOOLS

Providing travelers with information about more accessible, convenient routes through multimodal navigation tools can lead to increased use of alternative modes and reduced vehicle travel (VTPI, 2016).

- A study of employee commutes found that providing high quality navigation tools reduced vehicle use by 17% with shifts to walking, cycling, and transit modes. The study noted that the effectiveness of the planning tool depended on the quality of alternative modes available, conditions, and the availability of adequate information (RTA, 2003; VTPI, 2016).
- Researchers for a pilot program in a metropolitan area of Japan developed a travel planning system to help commuters choose routes with fewer carbon emissions. The program encouraged users to switch use of cars with public transportation, walking, or cycling. Using the tool, participants produced 20% fewer greenhouse gas emissions; decreased car use by 20%; increased walking and bicycling by 82%; and increased use of public transportation by 103% (Usui et al., 2008).



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SPOTLIGHT ON V2I TECHNOLOGIES

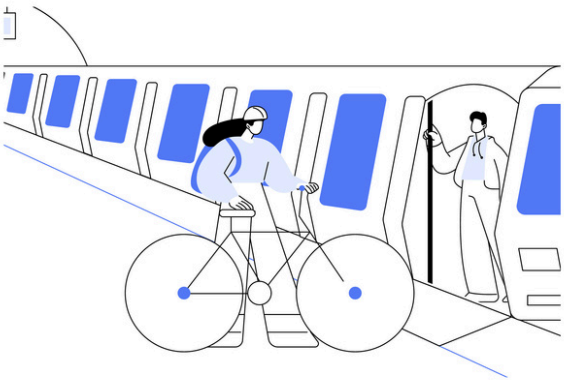
V2I can reduce trip time, congestion, and idling by providing real-time travel advisories and up to date roadway information for drivers to find alternate routes. The reduction of trip time, congestion, and idling can improve air quality and reduce greenhouse gas emissions (USDOT, 2022).

A study comparing the traffic safety and carbon dioxide emissions reduction of vehicle-to-vehicle (V2V) and V2I technology suggests these technologies can support GHG emissions reduction by approximately 5% for a density of 3000 vehicles/hour. Vehicles in the analysis included standard vehicles, slow vehicles, and trucks. The study noted the technology alert systems create vehicle speed harmonization, which reduces starts and stops as well as fuel emissions (Outay et al., 2019).

TRIP PLANNERS CAN ENCOURAGE MODAL SHIFT

Trip planning tools with modal integration encourage the use of alternative modes of travel, which can help reduce vehicle congestion.

An evaluation and survey of a multimodal trip planning tool, Multimodal Trip Planning System (MMPTS), based in Chicago, found that the tool helped new residents learn about and navigate the local transportation system (Biernbaum et al., 2011). The survey results showed a significant percentage of overall respondents (close to 40%) noted that the tool helped them use at least one new transit service. Around 50% of suburban respondents reported the same (Biernbaum et al., 2011).



CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Trip planning and modal integration can encourage the use of active transportation and public transit. Communities designed with pedestrians, transit riders, bicyclists, and other micromobility users in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways (Litman, 2024a).

Investment in active transportation can promote the perception and reality of safety. Safe and comfortable walking and biking infrastructure can also reduce the likelihood of vehicle-pedestrian and vehicle-bicycle fatalities and serious injuries (Boutros et al., 2023).

AIR QUALITY AND HEALTH

Reducing the number of emissions-emitting vehicles on the road (especially in densely populated areas) will decrease air pollutants that are harmful to human health. Trip planning tools can facilitate the use of alternative travel modes to support reduction of high emissions-emitting vehicles (Litman, 2024b).

RURAL COMMUNITIES

Trip planning tools are extending toward rural communities. Vermont and Minnesota have developed initiatives to bring trip planning tools to connect travelers to public transportation in rural areas, where previous investment has been lacking. In Vermont, the rural trip planning tool has seen a significant amount of usage with close to 20% of users planning transit trips involving walking, biking, and carpool and vanpool-matching between 2022-2023. The initiatives in Minnesota and Vermont are federally funded through the Accelerating Innovative Mobility Project and Mobility on Demand Sandbox grant, respectively (Pan, 2024).

COST SAVINGS

Trip planning and modal integration can increase awareness and utilization of public transit, which can lead to improved farebox recovery ratios. (*Farebox recovery is the percentage of operating costs recovered by transit passenger fares.)* Increased ridership is one way transit agencies can recover

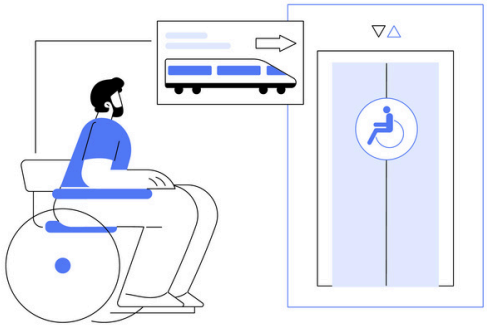
a higher percentage of operating costs (FTA, 2013).

Trip planning can result in traveler time and cost savings.

A study in Washington, DC simulated roadway travel trips with and without a pre-trip notification service that assisted in on-time arrivals. Using a framework to calculate the cost value of the time savings with on-time arrivals, travelers using the service received a net benefit of approximately $60 or more per year (Shah et al., 2003).

ECONOMIC GROWTH

Trip planning tools can facilitate awareness of and access to multimodal transportation options which also means more access to job and education centers, leading to economic opportunities. Increased use of public transit and associated foot traffic is also beneficial for small businesses near transit stations (USDOT, 2015).



A study in Phoenix, AZ examined the impact of the opening of a public transit light rail system on the start of new independent businesses in the vicinity. Over a 24 year period, the area had an 88% increase in new business starts in the knowledge sector, a 40% increase in the service sector, and a 28% increase in the retail sector. The study also noted these businesses were located mainly within a quarter mile of transit stations, with a significant decrease in new business starts 1 mile away from the transit stations (Credit, 2018).

ACCESSIBILITY AND EQUITY

Trip planning tools allow users to better access transportation modes around them. Access to mobility options increases access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities.

A study in Phoenix, AZ of the piloted Pass2Go smartphone app showed that out of 332 participants, 74% of users in the study reported the app improved access to public transportation. Out of the 24 study participants using the app's accessibility features, 75% rated the app 7/10 or higher, with 11 of those users with disabilities rating the app

8/10 or higher. The pilot is part of the FTA Mobility on Demand Sandbox program (Martin et al., 2020).

Active and public transportation are linked to decreased loneliness, increased access to family and friends, and greater levels of socialization (Williams et al., 2021; Litman, 2024b).

Accessibility is an important consideration to include in trip planning tools, as people with disabilities using the tools may need to consider various accessibility options, such as text-to-speech and American with Disabilities Act (ADA) infrastructural features. To support accessible commutes, trip planning tools can highlight features such as kneeling buses, curb ramps, elevators to station platforms, and communication signals for information and safety (Breitenbach, 2022).

A 2021 study developed a pedestrian wayfinding mobile application to assist people with disabilities to safely use and access sidewalks and pedestrian pathways. The study used feedback from users to develop and design the app, finding that "accessible entrances" was the top feature selected by wheelchair users (Singara, 2020).

Access or means to use the trip planning tools is an important equity consideration. Disadvantaged populations may lack access to smartphone technology or have limited internet connections to support trip planning apps. Low income populations may not have access to credit cards to pay electronically through multimodal planning apps (Breitenbach, 2022). To address this, agencies can consider access to trip planning tools by offering offline options and alternative payment methods.

Providing more travel options to users through trip planning tools can benefit those without vehicles or people with disabilities, leading to safer, more convenient, and accessible travel (VTPI, 2016).

Findings from a 2022 Mobility Assistance for People with Cognitive Disabilities (MAPCD) study show that a wayfinding smartphone application with advanced accessibility features helped participants with cognitive disabilities navigate fixed-route buses independently. Around 87% of participants reported increased ability to use fixed-route buses more independently using the app, with its assistance in addressing barriers such as missing on-board announcements and navigating public transit systems (City of Columbus, 2021).

COST CONSIDERATIONS

The cost to implement trip planning tools varies widely depending on scale, scope, and location of the project.

Depending on the customization, software, and consolidation of data feeds, the initial development of multimodal trip planning tools can cost between $138,000 to $4 million on average (Biernbaum et al., 2011).

Trip planning tools can be developed and implemented in a variety of ways, depending on the needs of an organization, budget, and preferences. Options for cost effective open source resources further provide ease of implementation. The following are examples of open source software and services available for use by agencies and organizations to support trip planning and modal integration tools.

OpenTripPlanner is a multimodal open source trip planning software providing passenger information and transportation network analysis services. The software has an active community of developers supporting the system and keeping it up to date.

The Oregon TriMet system uses an open-source software, OpenTripPlanner, as part of its trip planner website. Integrating the open-source software cost $69,000 for the initial developer time investment and another $69,000 for the routing engine and interface (Biernbaum et al., 2011).

GraphHopper offers open source services to calculate routing such as distance, time, turn-by-turn instructions, and other route characteristics. It also offers a toolkit for solving vehicle routing problems through the tool jsprit.

Costs can be reduced if an organization has access to consolidated standardized databases and access to data feeds. Further reduction in costs results from the use of open-source software and data feeds.

Trip planning tools involve development and maintenance costs. Transit authorities typically must maintain static and regional data feeds, requiring investment in a general transit feed specification (GTFS). Annual maintenance costs are around 35% of the creation costs (Biernbaum et al., 2011).

- Costs for GFTS can vary depending on fare collection systems, difficult location stops, and other challenges.
- The labor required for the GTFS ranges from about 12 hours to 2 months, depending on existing database quality and compatibility of the operations scheduling software. Regional feeds have higher costs, particularly if they include multiple data feeds (Biernbaum et al., 2011).

Integrating V2I communication into roadside infrastructure has variable costs to implement and maintain. Infrastructure needed include wireless roadside units (RSU), backhaul telecommunications infrastructure, a Security Credential Management System for privacy-protected exchange of information, back office maintenance, and system monitoring and maintenance. Costs for each of these components vary by location, complexity, and scale. For example, RSU hardware can range from $900 to $8,226 per RSU, with design, integration, and testing costs in the range of $1,000 per RSU for installation and $101,000 for verification of 47 RSUs (NASEM, 2020).

FUNDING OPPORTUNITIES

Federal Highway Administration (FHWA) Flexible Funds: In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. CMAQ provides funding for V2I/ITS technologies, including travel advisories.

FHWA's **Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN)** ATTAIN and ATTIMD support programs support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance transportation system efficiency include implementing technology to integration of transportation service payment systems and implanting advanced mobility access and on-demand transportation service technologies.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Eligible projects include connected vehicles, aviation innovation, smart grid, and traffic signal innovation.

FHWA's **Saving Lives with Connectivity: Accelerating V2X Deployment** grant program will fund projects that advance connected and interoperable vehicle technologies. Connected and interoperable vehicle technologies have the potential to greatly reduce motor vehicle crashes and resultant fatalities, injuries and property damage.

DOE's **New Mobility Systems** funding supports cooperative driving automation (CDA) in vehicles enabled by low-cost infrastructure upgrades or novel applications.

DOE's **ARPA-E NEXTCAR Program** supports research to enable technologies that use connectivity and automation to co-optimize vehicle dynamic controls and powertrain operation, thereby reducing energy consumption of the vehicle. These technologies have the potential to reduce congestion and increase the safety and efficiency of travel on roadways.

FHWA's **Exploratory Advanced Research (EAR) Program** is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

USDOT offers grant funding to enhance intermodal efficiency through several programs, including the **Reduction of Truck Emissions at Port Facilities Grant Program**, the **National Highway Freight Program (NHFP)**, and the **Accelerated Innovation Deployment Demonstration Program**.

COMPLEMENTARY STRATEGIES

Supporting low carbon trip planning and modal integration requires the availability of multimodal options for travelers to be able to use and plan connected trips that are not reliant on single occupancy vehicles. Coordinated transportation planning can support the vision of a network of connected transport and transit options for efficient and convenient travel by ensuring different modes are coordinated and planned effectively with lower carbon options.

TOD and trip planning and modal integration are closely linked. TOD facilitates trip planning by providing easy access to transit options. Trip planning and modal integration can be attractive to TOD residents and visitors, allowing them to easily plan trips using digital, real-time trip planning tools and apps, while knowing that stations are conveniently located and well-connected to their destinations.

By integrating transit and providing travelers with the trip planning and modal integration tools they need to plan their journeys effectively, communities can encourage more people to use public transportation.

View All Strategies

CASE STUDIES

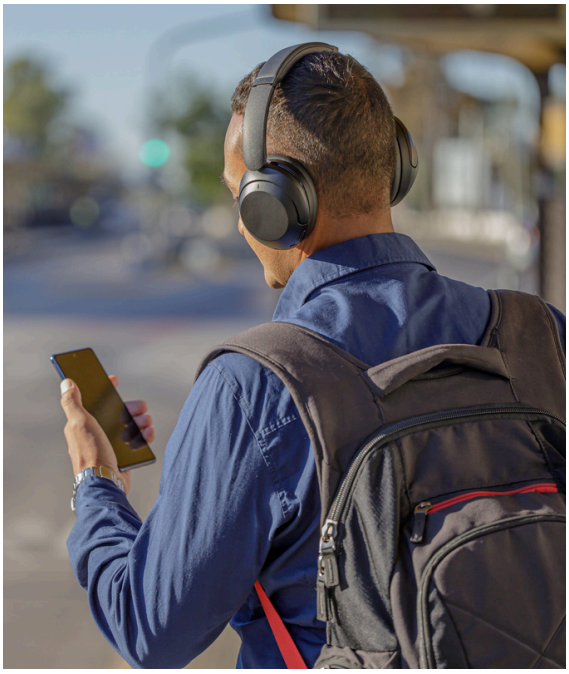
MONTGOMERY COUNTY, MD DOT RIDE ON TRIP PLANNING APP

Montgomery County launched the Ride On Trip Planner App allowing travelers to plan routes in advance and track buses in real time. The app was released alongside efforts to increase accessibility and adjust services based on ridership, among other initiatives, to make the transit network faster. Increased bus ridership is part of the county's 2023 climate goal.

(Source: Montgomery County DOT)

COLUMBUS, OH MULTIMODAL TRIP PLANNING APP

Columbus, OH developed a multimodal trip planning app for residents to access a range of travel options. The Pivot app allows residents to find the best way to a destination and book payments for the services across transport modes of walking, public transit, ridehailing, bike and ride sharing, vehicles, and biking. The app aims to reduce vehicle traffic, increase access to multimodal transportation, and reduce reliance on vehicle travel, in turn reducing congestion and emissions.



CALIFORNIA INTEGRATED TRAVEL PROJECT (CALITP)

The California Integrated Travel Project (CalITP) is a travel integration tool bringing the payment systems of hundreds of public transit providers across the State of California into one app. By simplifying the payment structure, CalITP makes it easier for travelers to use more carbon efficient modes of transportation, reduces transit agency operating costs, and provides a user-friendly system to make travel by transit quicker and more efficient.

SFMTA MULTIMODAL TRIP PLANNING TOOL AND ASSISTANCE

The San Francisco Municipal Transportation Agency (SFMTA) has a multimodal trip planning tool incorporating public transit, walking, biking, drive and park, and taxi travel modes, with a range of accessibility features. To assist travelers, especially older adults and people with disabilities, in using the tool and planning trips, SFMTA provides free, pre-scheduled individual and group travel training sessions. The training sessions can include sharing recommendations for navigating multimodal trips, providing lessons on accessing accessibility features, offering practice riding public transit with a travel assistant, and improving skills and confidence to use multiple modes of transportation (SFMTA, 2013).

IMPLEMENTING TRIP PLANNING TOOLS AND MODAL INTEGRATION: **WHAT TO READ NEXT**

The U.S. DOT Intelligent Transportation Systems Professional Capacity Building Program provides a range of resources, such as trainings, webinars, peer exchanges, and academic resources on ITS, including resources on connected vehicle deployment and third party transit information and trip planning.

The U.S. DOT Intelligent Transportation Systems Joint Office Program offers several publications and information on V2I deployment, analysis, safety, and licensing.

FHWA's Integrating Shared Mobility into Multimodal Transportation Planning: Improving Regional Performance to Meet Public Goals is a framework transportation agencies, local governments, and MPOs can plan to integrate multimodal transportation practices, and can lay the groundwork for trip planning tools to then be developed and implemented.

Guide to Licensing Dedicated Short Range Communications for Road Side Units is a resource with best practices and information on licensing requirements for organizations seeking services to support V2I applications.

RESOURCES

GENERAL RESOURCES

FTA National Transit Database (NTD): FTA requires transit agencies to upload financial, operational, and asset conditions data to the NTD on an annual basis. The publicly available NTD provides data to inform decision making at all government levels, in addition to providing information to the private sector and for research.

- In 2023, FTA began requiring transit agencies to submit a link to their updated General Transit Feed Specification (GTFS) as part of the NTD reporting. This requirement encourages transit agencies to publish their data on GTFS, which feeds into other trip planning tools. Annual updates to GTFS will help trip planning tools to stay current and accurate.

EPA Smart Location Database analyzes a wide array of indicators relevant to the built environment and location efficiency, to better understand the impacts of land use on transportation outcomes. The Database allows users to measure the location efficiency and convenience at the census block level, with indicators such as housing density, urban design, transit access, and more.

America Planning Association Open Sources: This list of open source tools for multimodal planning offers resources for modal integration tools to be developed by planners and practitioners.

FHWA CARMA Program: This program is leading research on cooperative driving automation (CDA) which would enable communication and cooperation between properly equipped vehicles and infrastructure.

TOOLKITS AND MODELLING APPROACHES

The National Renewable Energy Laboratory has developed several simulation and modeling tools. These tools allow users to estimate and evaluate impacts of transportation and land use decisions on emissions and energy use, among others, to support data-driven decision making to maximize the potential for emissions reductions.

- Open Platform for Agile Trip Heuristics (OpenPATH): This is an open-source application that allows users to track their mode of transportation and measure the associated emissions and energy use.
- Route Energy Prediction Model (RoutE):The tool allows users to create data-informed energy consumption models for any vehicle type (existing and futuristic).

- Transportation Energy & Mobility Pathway Options Model (TEMPO): This is a comprehensive travel demand model that can develop long-term scenarios to evaluate energy use, emissions, and impact on energy supply/systems.
- Mobility Energy Productivity Tool (MEP): The tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

DOE Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics, for insight on the interconnected impacts between transportation and land use decisions.

WORKING WITH COMMUNITIES

Open Street Map: This is a platform allowing users to digitally map and record street infrastructure. The data from Open Street Map can be useful for trip planning tools, as information as detailed as sidewalk size is recorded and can help pedestrians understand walking environments within neighborhoods.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

VEHICLE ENERGY EFFICIENCY IMPROVEMENTS

Increasing vehicle efficiency through stringent and achievable fuel economy standards and improved engines, lightweight, recycled materials, and hybridization can reduce fuel use and improve air quality.

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OVERVIEW

Best Suited for:
Short Term
Urban, Suburban, Rural & Tribal

Achieving the long-term goal of decarbonizing the transportation sector requires transitioning to cleaner vehicles and fuels. However, it is also critical to continue improving vehicle efficiency through improved engines, rightsizing, more extensive use of lightweight materials, enhanced aerodynamics, and hybridization of power sources. Conventional vehicles with internal combustion engines, which includes hybrid electric and plug-in hybrid vehicles, will continue to be sold and driven over the coming decades – improving their efficiency will be an important lever to reducing greenhouse gas (GHG) emissions from the transportation sector. Similarly, efficiency improvements for zero-emission vehicles, such as those powered by batteries, will reduce the electricity demand from their use by extending their driving range for the same given amount of energy.

More efficient electric vehicles (EVs) enable the use of smaller batteries without affecting driving range. This lowers the cost of the vehicle and reduces the amount of critical minerals needed. Efficiency improvements for EVs also means lower cost of operation because less energy is being purchased for the same driving range, which could incentivize their adoption.

Regulations and Standards:
Industry leadership on fuel-efficient vehicles has led to widespread standardization and innovation as companies work to keep pace with new regulations and standards. According to EPA's 2024 Automotive Trends Report, average estimated real-world fuel economy of model year (MY) 2023 passenger vehicles in the U.S. was 27.1 mpg, an increase of 1.1 mpg from 2022. The National Highway Traffic Safety Administration's (NHTSA) Corporate Average Fuel Economy (CAFE) standards regulate how far vehicles must travel on a gallon of fuel, while EPA's emissions standards set limits on criteria pollutants and GHG emissions from vehicles and engines. Together, these standards support a trend towards a more efficient vehicle fleet with cost savings for individuals and households.

Consumer Behavior: Consumer preferences are important considerations in the overall shift toward more efficient and zero emission vehicles. In the U.S., passenger vehicles are trending larger and heavier; larger vehicles, like SUVs and large pickup trucks, are inherently less fuel-efficient than smaller sedans. Federal and state incentives and tax credits can encourage the purchase of more efficient vehicles.

CAV and V2X: Vehicle-to-everything (V2X) and connected and automated vehicle (CAV) technologies can play an important role in improving vehicle efficiency. Based on recent connected vehicle and V2X deployments in the USDOT's Intelligent Transportation Systems Joint Program Office Benefits Database, technologies like adaptive cooperative cruise control and adaptive signal systems can reduce fuel consumption and, thus, CO_2 emissions by 10% or more. Many CAV techniques can also help to smooth the drive cycle, reducing emissions from stop-and-go behavior (ITS JPO, n.d.). Refer to the Intelligent Transportation System page for more information.

Heavy-Duty Efficiency: Heavy-duty vehicles have relatively low fuel economy due to their large size and weight. The implementation of technologies and devices, such as advanced cruise control, gap reducers, and low-rolling resistance tires, can significantly improve the efficiency of trucks and tractor-trailers. Training materials focused on efficient driving techniques, like utilizing cruise control, following speed limits, and removing excess weight, can teach drivers how to improve their fuel economy. Idle reduction technologies, like truck stop electrification, automatic engine shutdown/startup systems, and auxiliary power units, also help reduce fuel consumption and improve overall efficiency.

> *The European Union (EU) has the strictest fuel efficiency standards globally. In 2020, the EU introduced new performance standards and declared that new vehicles must contain on-board fuel consumption meters and manufacturers must report the averaged results. In 2023, these standards were strengthened to a goal of 100% zero emissions from tail pipes by 2035. Average CO_2 emissions from new cars declined by 12% from 2019 to 2020 and 12.5% from 2020 to 2021 (European Commission, n.d.).*

> *Rail companies are implementing new technologies to improve fuel economy. Examples include:*
> - *Anti-idling systems*
> - *Distributed power*
> - *Biodiesel and renewable fuels*
> - *Fuel management systems*
>
> *(ARR, n.d.)*

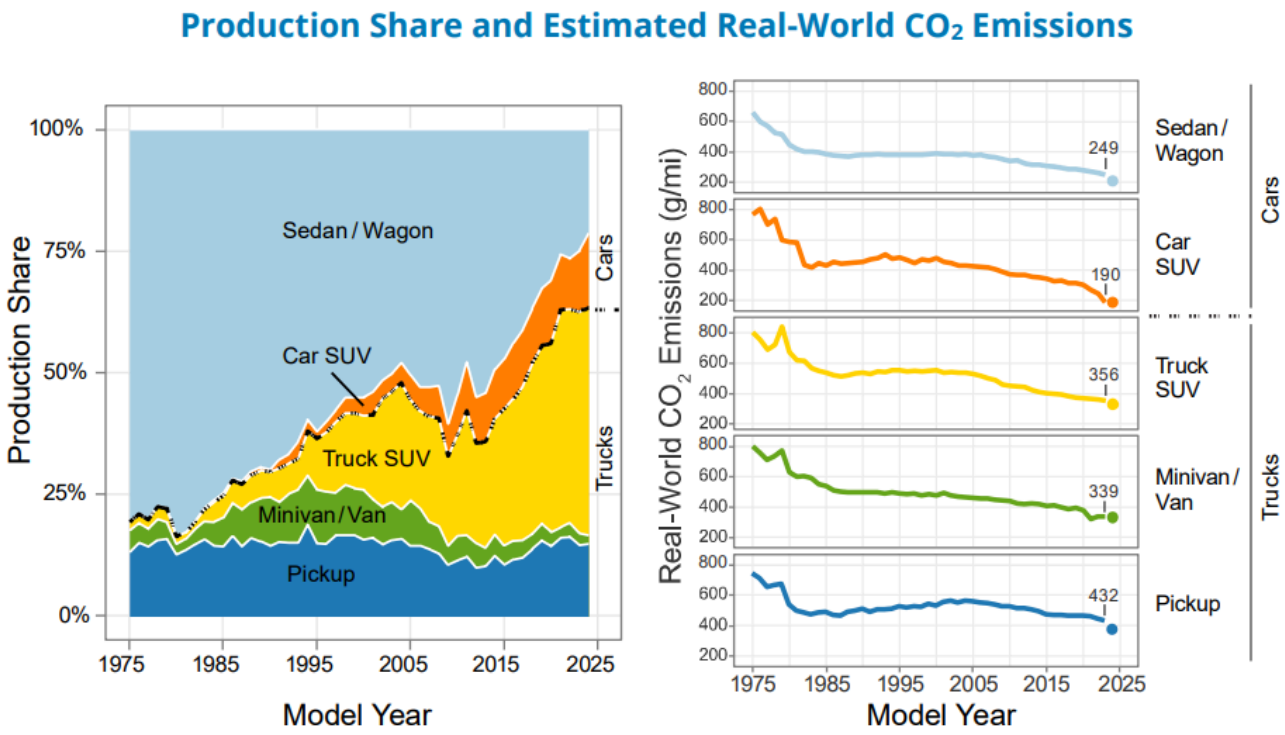
GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

FUEL ECONOMY TRENDS

Each year, the EPA publishes an automotive trends report showing changes in CO_2 emissions and fuel economy. The 2024 report marks the 50th anniversary of the report and EPA's continued partnership with the automotive industry to provide data-driven insights into the U.S. vehicle fleets. Model Year 2023 passenger vehicles had the lowest average CO_2 emission rate (319 g/mile) and highest fuel economy (27.1 miles per gallon, or mpg) on record. Increased production of battery electric vehicles (BEV) and plug-in hybrids had significant impacts on the overall trends.

Truck sport utility vehicle (SUV) production share reached a record high of 45% in 2023, while car SUV production reached 12%. CO_2 emissions from 2023 car SUVs decreased sharply with model year 2023, by 24% to 60 g/mile, primarily due to the introduction of new BEV models (EPA, 2024d).



Source: EPA, 2024d

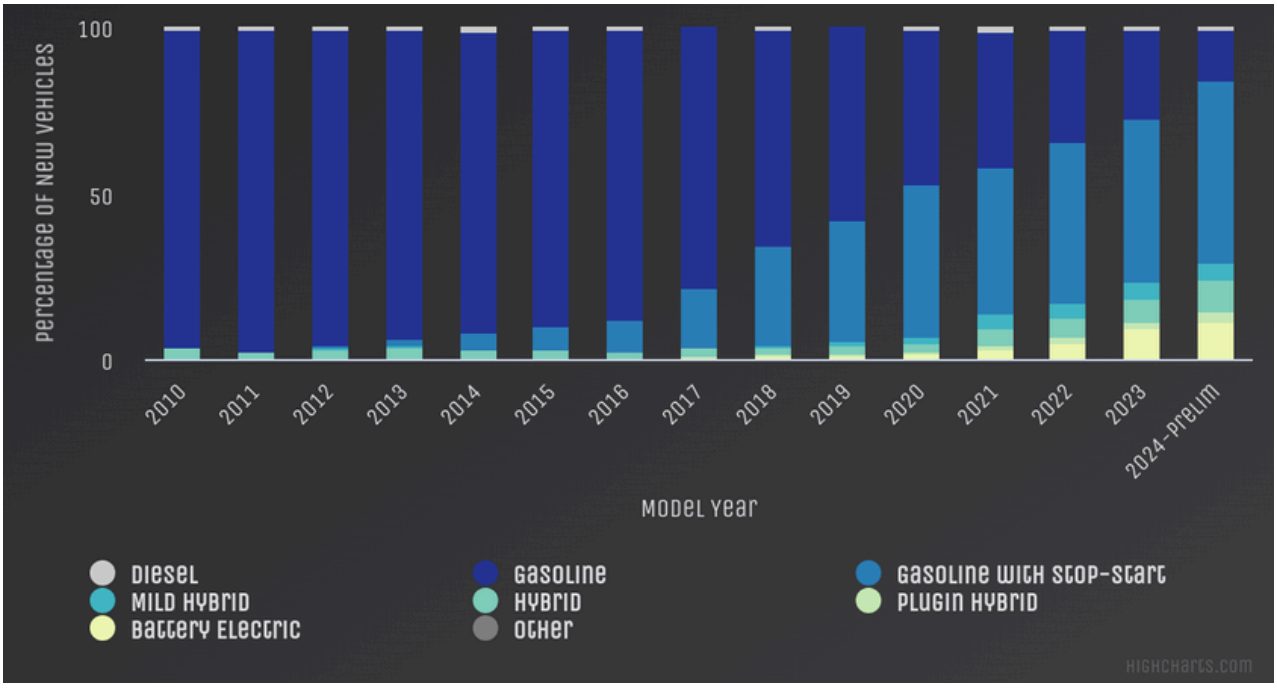
JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations | Funding Opportunities | Complementary Strategies | Case Studies | What to Read Next | Resources

The U.S. average mpg rating increased from 13.1 mpg in 1975 to 27.1 mpg in 2023. Model year 2023 vehicles emitted 50% less CO_2 per mile compared with 1975 models and 31% less compared with 2004 (EPA, 2024d).

CO_2 emissions from all vehicle classes have decreased substantially over the last few decades due to improved fuel economy. However, the emissions benefits have been partially offset by U.S. consumer preference towards larger vehicles (EPA, 2024d; Byun et al., 2017).

Emissions standards that target larger and inefficient vehicles result in the greatest potential impact. For example, increasing the fuel efficiency of a vehicle with 10 miles per gallon (mpg) to 15 mpg will reduce annual CO_2 emissions by one-third (DOE, 2022c).

Over the period of 2017-2022, nine of the fourteen largest manufacturers selling vehicles in the U.S. decreased new vehicle estimated real-world CO_2 emission rates. These changes can be attributed to both vehicle design and the mix of vehicle types produced (i.e., more hybrid and electric vehicles) (EPA, 2024d).



Newer vehicle fleets are becoming cleaner and more efficient due to higher shares of electric and hybrid vehicles and implementation of start-stop technologies (EPA, 2024d).

VEHICLE EFFICIENCY IMPROVEMENTS

Substituting materials to reduce the weight of vehicles, also known as lightweighting, is one strategy to improve fuel efficiency. For vehicles with internal combustion engines, a 10% weight reduction can decrease fuel use (and thus emissions) by 6-8% (DOE, n.d.).

One study found that implementing existing powertrain improvements would lead to a 30% decrease in fuel consumption on average for light duty vehicles. In combination with lightweighting and hybridization, fuel consumption could decrease 50% on average (Leach et al., 2020).

For heavy-duty vehicles, CO_2 emissions reduction potential is 10-26% from aerodynamic drag improvements, up to 10% from adding a bottoming cycle, up to 30% from trailer and weight size increases, and up to 10% from reduced road speed. The upfront cost of these technologies is paid back through the resulting reductions in fuel use (Cooper et al., 2009).

Hybrid vehicles utilize regenerative braking, electric motor drive/assist, and automatic stop/start technologies to reduce gasoline use and tailpipe emissions. Switching from a gasoline-powered vehicle to a hybrid vehicle reduces annual emissions by 45% on average (AFDC, 2022).

LIFECYCLE EMISSIONS

Around one-tenth of lifecycle emissions for gasoline vehicles and one-quarter for battery electric vehicles stem from production (Elgowainy et al., 2021). More efficient production methods, such as producing metals from recycled scrap and implementing plastic recycling programs, are up to 60-90% less energy intensive (IEA, 2019).

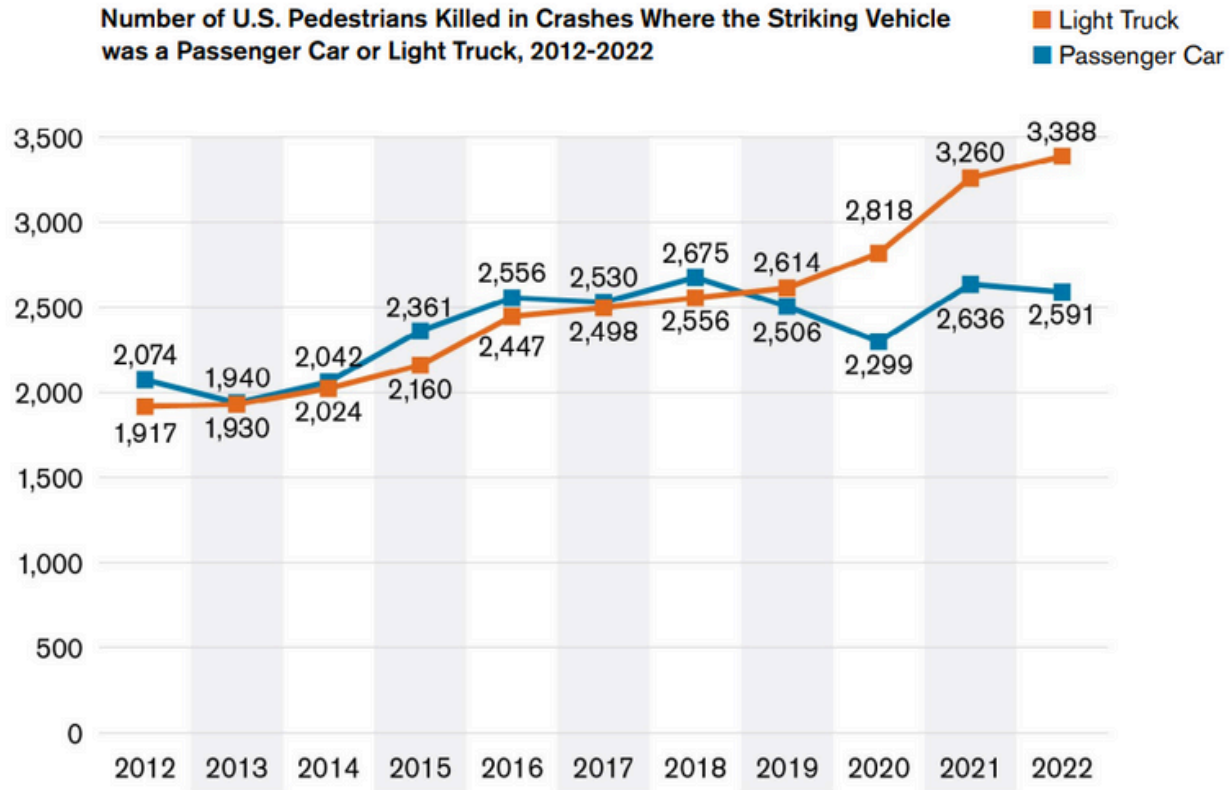
Substituting conventional materials with lightweight materials can significantly reduce lifecycle GHG emissions from light-duty vehicles. In one modeling study, aluminum was shown to reduce cumulative lifecycle GHG emissions (2016 to 2050) from the fleet by 5.6% (2.9 Gt CO_2e) and annual emissions in 2050 by 11% (Milovanoff et al., 2019).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Smaller vehicles are more fuel efficient and improve road safety by reducing risk to vulnerable road co-users, such as pedestrians and bikers (Rose, 2023). One study estimated that a pedestrian is 70% more likely to die if the involved vehicle in a crash is a pickup truck rather than a car, and death is twice as likely if the vehicle is a large SUV rather than a car (Tyndall, 2024).



Source: GHSA, 2024

ACCESSIBILITY AND EQUITY

Fuel economy standards reduce long-term costs to consumers by producing savings on fuel costs. Since transportation is the second largest cost for low-income households, this means significant cost savings for lower-income car and truck owners. New vehicle fuel economy standards issued by the National Highway Traffic Safety Administration will save passenger car and light truck owners more than $600 in fuel over their vehicle's lifetime (NHTSA, 2024b).

In California, the Enhanced Fleet Modernization Program provides low-income drivers $1,500 to scrap their high-polluting vehicle, and $4,500 if they also purchase a cleaner, fuel-efficient vehicle. As of September 2023, 18,387 vehicles had been replaced through the program (CARB, 2023).

AIR QUALITY AND HEALTH

EPA's emission standards help reduce vehicle emissions of harmful air pollutants, which disproportionately impact environmental justice communities (EPA, 2024a).

It is estimated that the EPA vehicle standards finalized in 2024 will lead to 41,400 fewer premature deaths, 63,600 fewer emergency room visits, 25.5 million fewer asthma attacks, and 9.3 million fewer lost work and school days between 2027 and 2055 (Environmental Defense Fund, 2024). See the EPA's Regulations for Onroad Vehicles and Engines for the latest on vehicle emissions standards.

COST SAVINGS

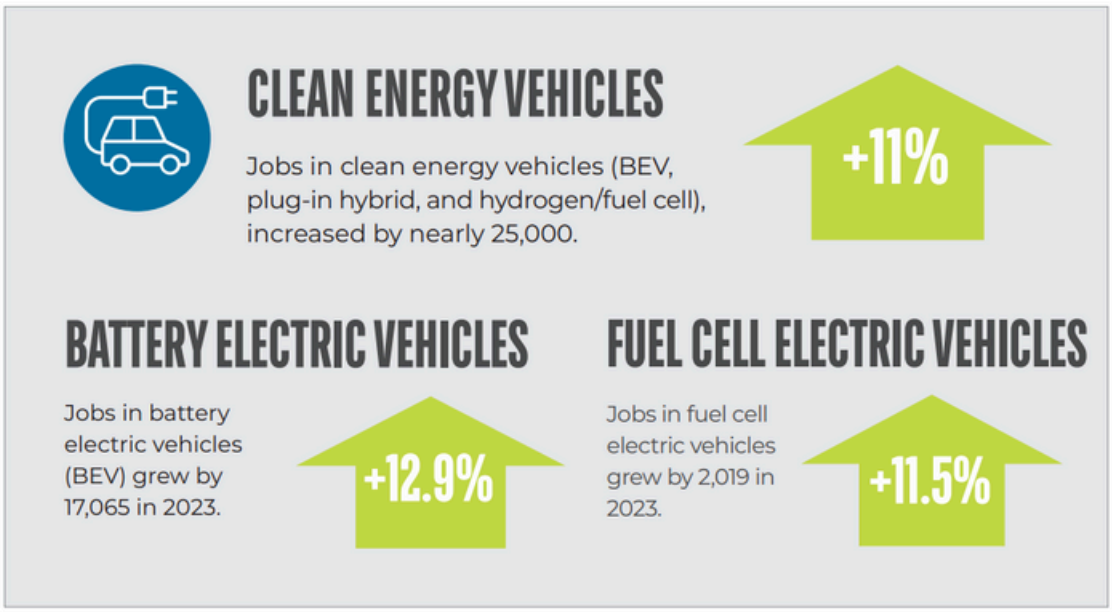
New vehicle fuel economy standards will save Americans more than $23 billion in fuel costs. These increases will bring the average light-duty vehicle fuel economy up to approximately 50.4 miles per gallon by model year 2031, saving passenger car and light truck owners more than $600 in fuel over the lifetime of their vehicles. New standards will also result in a fleetwide average of approximately 35 miles per gallon by model year 2035, saving heavy-duty pickup and van owners more than $700 in fuel over the lifetime of their vehicles (NHTSA, 2024b).

Fuel standards for light-duty vehicles finalized by the EPA in March 2024 would save American drivers an estimated $6,000 each, on average (EPA, 2024b).

The final Corporate Average Fuel Economy (CAFE) standards for passenger cars and trucks for model year 2027 and beyond are predicted to save consumers over $50 billion on fuel costs across vehicle lifetimes (NHTSA, 2024a).

ECONOMIC GROWTH

Motor vehicle jobs are growing, and the most rapid growth is in zero-emission vehicles. From 2022 to 2023 jobs in clean vehicles (BEV, plug-in hybrid, and hydrogen/fuel cell) increased by 11%, adding almost 25,000 jobs (DOE, 2024).



Source: DOE, 2024

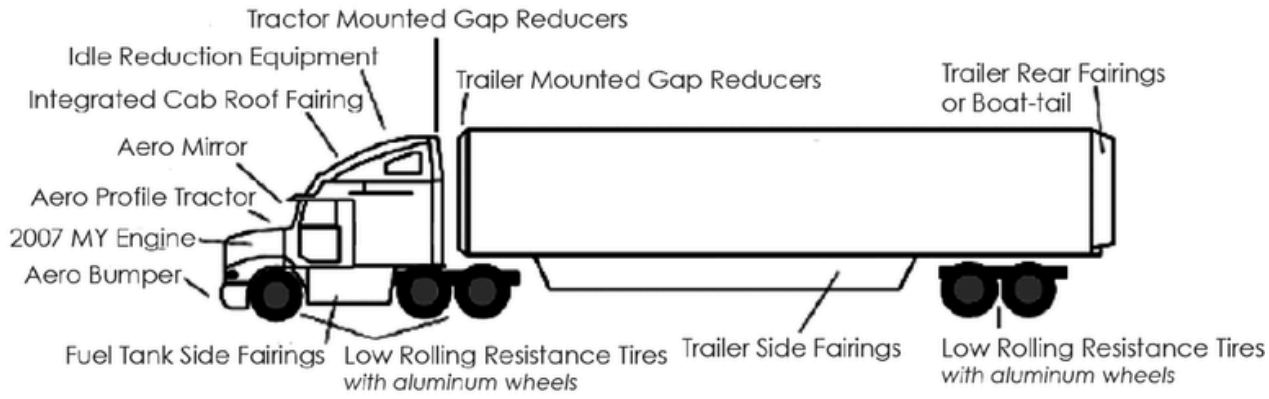
EPA's final standards for light-duty and medium duty vehicles are expected to provide nearly $100 billion of annual net benefits to society, including $13 billion of annual public health benefits due to improved air quality and $62 billion in reduced annual fuel, maintenance, and repair costs for drivers (EPA, 2024a).

EPA's final standards for heavy-duty vehicles are expected to provide savings for truck owners and operators once they are fully implemented. For example, vehicle purchase tax credits provide savings on upfront costs, and additional costs are recouped through savings on maintenance and fuel within two to five years. These savings are expected to range between $3,700 and $10,500 annually, depending on the type of vehicle (EPA, 2024b).

COST CONSIDERATIONS

The cost to implement vehicle energy efficiency improvements varies widely depending on the scale, scope, and location of the project.

SmartWay is a voluntary EPA program that helps freight companies reduce their emissions and reach sustainability goals. The lifetime cost savings based on 15 years of ownership is predicted to be $23,600 per vehicle due to a 17.8% reduction in fuel consumption. Advanced SmartWay technologies provide cost savings of $55,800 over the vehicle lifetime and a 27.9% reduction in fuel consumption (Cooper et al., 2009).



SMARTWAY Equipment standards for heavy duty vehicles (Cooper et al., 2009).

A study of fuel efficiency standards for tractor-trailers in the EU found that available efficiency technologies can reduce fuel consumption by 27% and payback the cost of implementation in as little as a year. More advanced efficiency technologies can reduce fuel consumption by 43% and payback the cost in 1.9 years (Meszler et al., 2018).

FUNDING OPPORTUNITIES

DOE's **The EERE Vehicle Technologies Office's research on energy efficient mobility systems** focuses on optimizing the overall transportation system to improve the affordability, efficiency, safety, and accessibility of transportation. EERE offers funding for research and development (R&D) to advance clean energy technologies.

EPA's **Diesel Emissions Reduction Act (DERA) Program** provides funding assistance to accelerate the upgrade, retrofit, and turnover of the legacy diesel fleet. Eligible diesel emissions reduction solutions include verified retrofit, idle reduction and aerodynamic technologies, and certified engine, vehicle, or equipment replacement. The Diesel Emissions Quantifier (DEQ) tool is used to estimate reductions in CO_2 and other air pollutants from DERA projects.

FAA's **Fueling Aviation's Sustainable Transition (FAST) Grants** program will make investments to accelerate production and use of sustainable aviation fuels (SAF) and the development of low-emission aviation technologies to support the U.S. aviation climate goal to achieve net zero greenhouse gas emissions by 2050. The FAST Grant Program is made possible by the Inflation Reduction Act of 2022.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. The Bipartisan Infrastructure Law continues the CMAQ Program to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act, including supporting vehicle efficiency improvements.

DOT's **Maritime Environmental and Technical Assistance (META) Program** supports the research, demonstration, and development of emerging technologies that improve maritime industrial environmental sustainability and efficiency. The META program has supported research and demonstration technologies such as exhaust gas treatment systems, thermal energy harvesting, and general energy efficiency measures for ships.

EPA's **SmartWay** program provides freight companies engaged in shipping, carrying, or logistics free tools to track and report emissions and maintains lists of SmartWay-verified technologies. The program helps companies improve their efficiency and reach sustainability goals. SmartWay-verified technologies include aerodynamic devices, idling reduction equipment, and new and retread low rolling resistance tires. EPA also designates tractors and trailers equipped with certain combinations of EPA-verified technologies as SmartWay Tractors and Trailers.

COMPLEMENTARY STRATEGIES

HEAVY DUTY DIESEL ENGINE RETROFIT

Retrofitting heavy-duty vehicles with new, fuel-saving engines or engine components is a cost-effective strategy that improves vehicle energy efficiency.

IDLE REDUCTION TECHNOLOGIES & STRATEGIES

Reducing idling reduced excess fuel consumption resulting in better fuel economy and lower emissions.

INTELLIGENT TRANSPORTATION SYSTEMS

Eco-driving optimizes fuel usage by reducing stops and gear shifts to improve the efficiency of the vehicle.

View All Strategies

CASE STUDIES

LOCOMOTIVE IDLING RULE - CALIFORNIA

California's Air Resources Board passed a rule in 2023 to reduce emissions from locomotives operating in the state. The rule requires locomotives to limit idling time to 30-minutes and requires that locomotives, built in 2030 or after, operate in zero-emissions configurations when in California.

IDLE REDUCTION PROJECT - MISSOULA, MT

The Missoula Rail Link Railyard installed auxiliary power units on eight switcher locomotives and changed the mandatory idling policy to fit daily temperature conditions to save fuel and reduce emissions. The installation of auxiliary power units was partially funded by a 2009 Diesel Emission Reduction Act (DERA) grant from EPA. The project resulted in a 95% annual reduction in nitrogen oxide emissions due to idling, an 89% annual reduction in particulate matter 10 emissions due to idling, and an annual average of $235,964 in fuel savings.

95%
Annual Reduction in NO Emissions

89%
Annual Reduction in PM_{10} Emissions

$236K
Annual Average Fuel Savings

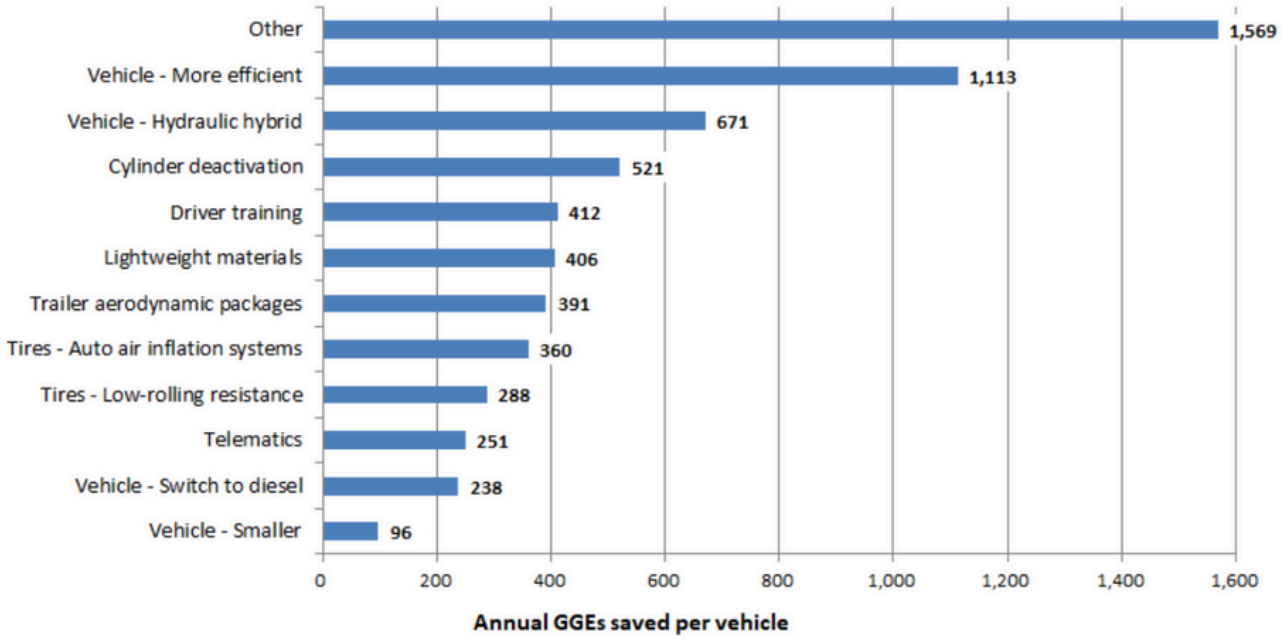
ADVANCED CLEAN CARS STANDARDS - CALIFORNIA

Under the federal Clean Air Act, California has set tailpipe emission standards for GHGs and criteria pollutants for light- and heavy-duty vehicles that are distinct from federal standards. Thirteen other states and Washington D.C. have voluntarily adopted the California standards. In 2022 the California Air Resources Board adopted the Advanced Clean Cars II standards, which regulate GHG and criteria pollutant emissions from new light-duty vehicles for model year 2026 to 2035. The standards require that all new light-duty vehicles sold in the state by 2035 have zero emissions.

FUEL ECONOMY PROJECTS - CLEAN CITIES COALITIONS 2022

Different strategies were used for 2022 Clean Cities coalition projects to improve vehicle efficiency. The figure to the left shows the reduction in gasoline gallons equivalent (GGEs), on average per vehicle annually.

Average Energy Saved per Vehicle for Various Fuel Economy Projects
(Source: Clean Cities Coalitions 2022 Activity Report, 2022).



IMPLEMENTING VEHICLE ENERGY EFFICIENCY IMPROVEMENTS: **WHAT TO READ NEXT**

The EPA and DOE maintain many resources on vehicle energy efficiency, including:

FuelEconomy.gov is the official U.S. government source for fuel economy information. Visit this site to compare fuel economy for different car models, learn more about EPA's ratings, and to access resources on advanced car technologies and fuels.

EPA's main Fuel Economy website provides links to current emissions regulations and automotive trends.

DOE's Energy Saver – Fuel Economy site provides additional fuel economy resources, including driving tips and maintenance tips to maximize efficiency.

While federal regulations are one of the most impactful levers on energy efficiency, state and local governments also play an important role. See State Laws and Incentives related to alternative fuels and advanced vehicles on DOE's Alternative Fuels Data Center site here.

Local governments can implement incentives to discourage the purchase of larger vehicles. Smaller vehicles not only have better fuel economy on average, but also are less likely to significantly injure pedestrians and other vulnerable road users in the event of a crash (NSC, 2024).

Denver, Colorado proposed legislation that would implement a vehicle weight fee and use the money collected for pedestrian safety (Kreutter, 2023).

Washington, D.C. charges higher vehicle registration fees for larger vehicles (Lazo, 2022).

RESOURCES

GENERAL RESOURCES

EPA SmartWay Verified Technologies: This webpage includes information on verified technologies for fleet managers and technology manufacturers and dealers.

EPA Fuel Economy Labels: The EPA published fuel economy labels for all new vehicles including electric cars and plug-in hybrids. The Fuel Economy Label includes information on fuel economy, fuel costs, and environmental impacts such as smog and GHG ratings.

EPA Vehicle Testing Regulations: This webpage includes links to relevant EPA regulations.

EPA Green Vehicle Guide: This guide helps the public find information on vehicles that are more efficient and less polluting.

DOE 2024 Fuel Economy Guide: This guide includes the most recent information on fuel efficiency, outlining strategies to reduce costs and fuel use.

TOOLKITS AND MODELLING APPROACHES

Global Fuel Economy Initiative Global Fuel Economy Toolkit: This toolkit details policy approaches based on vehicle type and provides case studies from across the globe.

DOE Alternative Fuels Data Center Tools: This webpage offers numerous tools to estimate fuel use and cost by vehicle type, compare fuel types, and more.

WORKING WITH COMMUNITIES

DOE Efficient Driving Strategies: These strategies share how drivers can maximize their vehicle's efficiency and estimate the resulting savings.

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center

U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

ZONING REFORMS

Updating zoning and other land use codes, regulations, or policies to foster denser mixed-use development promotes livable, connected communities with increased opportunities for transit use, walking, and biking.

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OVERVIEW

Best Suited for:
Long Term
Urban, Suburban, Rural & Tribal

Since the 1950s, conventional land use codes, regulations, and have led to land-use patterns that have significantly increased transportation-related greenhouse gas (GHG) emissions. This has left many individuals entirely reliant on vehicles to make trips to and from home. Zoning codes often require strict separation of uses (e.g., residential and commercial districts) and single-family housing on lots of a required minimum size. This encourages sprawling development with longer distances between homes and destinations. These provisions have resulted in car-dependent communities with limited consumer choice on transportation mode or residence type. In addition, high housing costs and limited supply in areas close to jobs and transit can lead to displacement, with people moving farther away to find affordable housing, leading to longer commutes and more trips made by car.

Traditional zoning codes and associated maps often require strict separation of uses. (Source: The Urban Institute)

Did you know?

Today, on 75% of all residential land in the US, only a detached single-family house is permitted on each lot (Badger and Bui, 2019).

Updating land use codes, regulations, and policies to increase housing supply and encourage compact, mixed-use, and mixed-income development with convenient access to active transportation and public transit can reverse this trend. Resulting communities would be more inclusive of diverse income levels, supported by convenient transportation options, and would increase location affordability.

Low-density residential developments, separated from other uses, are often less walkable and require personal vehicle travel.

Medium- or high-density residential developments, connected to other uses, are often more walkable and reduce reliance on personal vehicles.

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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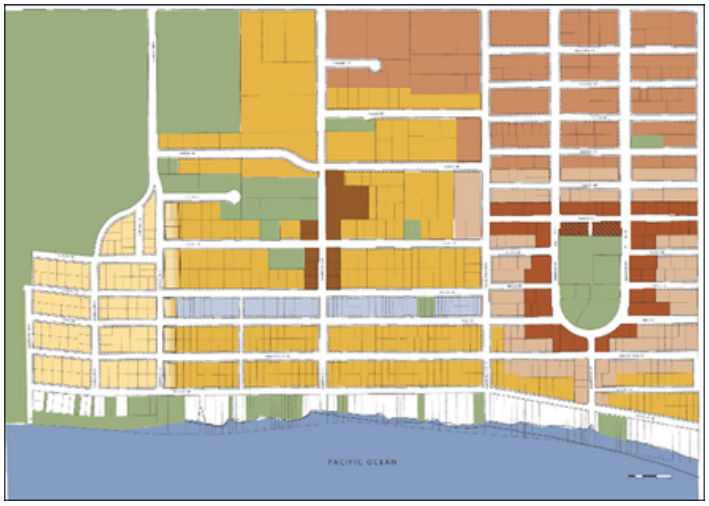


Performance-based zoning or form-based zoning, and associated maps such as this "regulating plan," focus more on the physical form and characteristics of buildings and their relationship to the surrounding environment rather than strict land use categories. (Source: Form-Based Codes Institute)

States and local communities can craft zoning codes, regulations, and policies to encourage more housing supply in transit-oriented areas and suburban and rural town centers. Zoning is often a local responsibility. However, the **federal government and state governments can encourage local governments to consider policies that support housing production, transit-oriented development (TOD), and walkable communities**. In suburban areas, this would mean easier access to shops and services as a wider variety of uses is woven into existing development. Communities can also support the preservation of existing affordable housing to help current residents stay in their transit-accessible neighborhoods in the face of new development pressures. All of these **policies can help limit the continued growth of distances between destinations by making it easier for people to live and work in locations with more transportation choices, including lower carbon-intensity modes – thereby reducing GHG emissions**. Land use reform that supports density can lead to the protection of natural, undeveloped land, since development growth is focused within a smaller area. Conserving land that would otherwise be developed can support resilience to extreme weather events and other climate impacts, further supporting climate goals.

Promoting density where transit access already exists helps more individuals reach destinations without the need for a personal vehicle. Density is a major factor in creating high-quality public transportation as riders can reach more destinations in less time, resulting in higher ridership and revenue. An increase in frequency and routes can continue to improve ridership, creating positive feedback effects. Protecting and redeveloping small urban cores, main streets, rural downtowns, and other pockets of high density development jointly promotes economic growth and decarbonization where people can take advantage of existing, denser forms of transportation.

Types of zoning amendments that communities can adopt to foster reduced transportation emissions include:

Transit Oriented Development (TOD): Enable and incentivize TOD, such as through overlay districts around public transit stations.

Increased Density and Mixed-Use Zoning: Allow and encourage higher-density development with a mix of residential, commercial, and retail space.

Traditional Neighborhood Development (TND): Enable and incentivize TND, a development strategy designed to mimic neighborhoods built prior to automobile-dependent suburban neighborhoods, such as through the establishment of standards and procedures for large, complex projects or through overlay districts.

Transferable Development Rights (TDR): Implement a voluntary, incentive-based TDR program that allows landowners in one area (i.e., an area targeted for conservation) to sell development rights from their land to another party who then can use these rights to increase the density of development at another designated location (i.e., an area targeted for growth).

Complete Streets Policies: Require streets to accommodate all users, including pedestrians, cyclists, and public transit.

Parking Reforms: Eliminate minimum parking requirements; for example, many conventional zoning codes require minimum parking standards that may be eliminated for most uses.

Pedestrian and Bicycle Oriented Design: Mandate the inclusion of bike lanes, sidewalks, and other pedestrian-friendly amenities in new developments.

Electric Vehicle Infrastructure: Require the installation of electric vehicle charging stations in new developments.

Green Building Standards: Implement green building standards that prioritize energy efficiency and sustainability in transportation-related infrastructure.

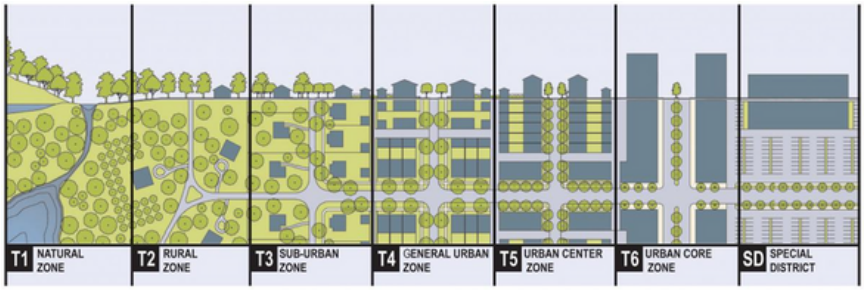
Incentives for Affordable Housing near Transit: Provide incentives for the development of affordable housing near transit hubs.

Transit Corridor Protection: Protect corridors from incompatible development to preserve and enhance transit service viability.

Alternatives to conventional zoning include:

Form-Based Codes

- Whereas conventional zoning codes focus on separation of uses, a form-based code is a land development regulation that fosters predictable built results and a high-quality public realm by using physical form as the organizing principle for the code. A form-based code is a regulation, not a mere guideline, adopted into city, town, or county law.
- More information on Form-Based Codes may be found on the Form-Based Codes Institute website.
- Many form-based codes are organized using the concept of a rural-to-urban "transect," which may be divided into six zones: and natural (T1), rural (T2), sub-urban (T3), general urban (T4), center (T5), and core (T6). The remaining category, Special District, applies to parts of the built environmental with specialty uses that do not fit into neighborhoods. Examples include power plants, airports, college campuses, and big-box power centers.



A version of the original transect diagram (Source: Congress for New Urbanism)

Performance Zoning

Performance zoning, sometimes called "impact zoning" or "flexible zoning," sets specific performance standards or criteria that developments must meet, rather than dictating specific land uses or building types. After these areas are identified and mapped, they are deducted from a site's development potential, and the remaining areas can then be developed at a density permitted by the zoning code. Instead of focusing on what activities are allowed in a particular zone, performance zoning concentrates on the outcomes or impacts of the development, such as traffic congestion, environmental quality, or aesthetic concerns. This approach allows for more flexibility and creativity in land use planning, fostering development strategies that reduce transportation emissions such as TOD (see the TOD page), while ensuring that developments meet certain standards, such as for air quality or pedestrian safety.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

INCREASING DENSITY CAN REDUCE EMISSIONS

A study by the California Air Pollution Control Officers Association (CAPCOA estimates that increasing residential density, job density, or street connectivity through zoning reform can each have up to about a 30% reduction in GHG emissions from vehicle miles traveled (VMT) at the project scale (no greater than a census tract). When combining these land use strategies through zoning reform, the GHG reduction potential can be up to 65% (CAPCOA, 2021).

Nationally, relative to a 2030 baseline, GHG emissions can be reduced by 0.2 to 3.5% through compact development, 0.10 to 0.31% through has the potential to reduce GHG emissions nationally by 0.2 to 3.5% from the 2030 baseline; pedestrian infrastructure improvements, and .009 to 0.28% through bicycle infrastructure improvements. (NASEM, 2012).

ZONING REFORMS DIRECTLY REDUCE EMISSIONS AND VMT

A study of three high-growth U.S. metropolitan areas found that local zoning reforms to accommodate housing growth along public transportation corridors and on underutilized urban land closer to downtown would reduce VMT by up to 13% and GHG emissions by up to 14% (Holland et al., 2023).

In Albuquerque, NM, a modeling study showed that ambitious zoning changes for more compact, infill land development would reduce transportation-related GHG emissions by about 20% in 2040 from the region's 2012 baseline (Tayarani et al., 2018).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

By encouraging mixed use development, promoting public transit, and implementing infrastructure for pedestrians and cyclists, zoning codes may be used to help encourage development that reduces the need for car travel, which in turn can decrease the likelihood of vehicle crashes. Additionally, reducing congestion through efficient land use planning can contribute to overall transportation safety by reducing the risk of vehicle-pedestrian collisions on low-speed roads (Retallack & Ostendorf, 2019).

COST SAVINGS

Past suburban and exurban development resulted in families moving further and further from downtowns and urban centers to find affordable housing. In doing so, they often incur higher transportation costs associated with the location of that housing. Shifting toward land use patterns that prioritize compact, mixed-use development easily accessed by public transit and active transportation can reduce transportation costs by reducing the need for car ownership, maintenance, fuel, and parking (Litman, 2024).

property values for residents and businesses, easier travel, reduced pollution, and economic stabilization of neighborhoods (EPA, n.d.).

ACCESSIBILITY AND EQUITY

Zoning reform that expands options for walking, biking, and riding transit increases access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities (VTPI, 2023).

AIR QUALITY AND HEALTH

Zoning for compact, mixed-use development that reduces the number of emissions-emitting vehicles on the road (especially in densely-populated areas) will decrease air pollutants that are harmful to human health (Litman, 2024).

Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities, especially communities of color, which are disproportionately located near major roadways (EPA, 2014; Jbaily et al., 2022).

RESILIENCE AND ADAPTATION

Adaptation strategies that support community density, like preservation of open green space, using greenways or other trails to mitigate flooding or heat impacts, or using multimodal hubs as evacuation points or heating/cooling centers for vulnerable populations help communities be more resilient to extreme events like floods (Davis et al., 2023; Ciabotti et al., 2023).

Rural communities can reduce emissions through smart zoning reform that is suitable in a rural context.

RURAL COMMUNITIES

Zoning reform can benefit rural communities by allowing for more flexible land use, and supporting efforts to reduce transportation-related GHG emissions. It can enable the development of affordable housing and mixed-use areas, including creating vibrant town centers with improved walkability, bikeability, and the ability for residents to live closer to work and amenities. Overall, it can help promote sustainable growth while preserving the unique character and environment of rural areas (Litman, 2024).

ECONOMIC GROWTH

Zoning reform that encourages compact, mixed-use, transit- oriented development that is conveniently accessed by multiple modes can reduce housing costs while stimulating economic growth by attracting commercial business and visitors (NASEM, 2004; Anagol et al., 2021). This can create jobs and generate revenue for local governments.

COST CONSIDERATIONS

COST EFFECTIVENESS

While there may be upfront costs associated with updating zoning codes and implementing changes, the long-term benefits can outweigh these expenses. For example, promoting compact, mixed-use development can reduce infrastructure costs by minimizing the need for new roads, utilities and other services.

According to one estimate, a shift toward public and active transportation and denser urban development would save $13 trillion throughout the public and private sectors by 2050, due to reduced costs for manufacturing, maintaining, fueling, and operating vehicles and building and maintaining associated infrastructure (Fulton and Reich, 2024).

By reducing air pollution and promoting active transportation, zoning reform can improve public health and reduce health care costs associated with respiratory illnesses and traffic accidents (Frank et al., 2006).

COST OF IMPLEMENTATION

The cost of zoning reform can vary depending on factors such as the scope of the reforms, the size of the community, and the extent of public engagement required. Potential costs to consider include consultant and planning fees, administrative costs, legal costs, and enforcement/compliance costs.

Although zoning reform allowing for more compact development can lower infrastructure costs per capita (accommodating a higher percentage of growth where infrastructure already exists), there may be marginal infrastructure costs of accommodating higher levels of density (e.g., sewer and water system upgrades) that communities need to be aware of. For example, construction costs have been shown to be higher with greater building height (Dong, 2023). However, benefits outweigh the costs of high density development, as less extensive networks are needed (California Planning Roundtable, 2002).

There are often opportunities to leverage funding from grants, partnerships, and other sources to support zoning reform efforts.

FUNDING OPPORTUNITIES

HUD's **Pathways to Removing Obstacles to Housing (PRO Housing)** empowers communities that are actively taking steps to remove barriers to affordable housing and seeking to increase housing production and lower housing costs for families over the long term. With a specific focus on the lacking access to affordable housing which disproportionately affects people of color, this program seeks to alleviate some of the historic zoning pressures that make housing inaccessible to many.

HUD's **Land Use Reforms and Off-Site Construction Research Grant** provides funding for communities to assess the potential for off-site construction methods to increase housing supply and study the impacts of local zoning and other land use regulations that can increase the supply of quality, affordable housing. The increased density associated with greater housing supply is more conducive to high-quality public transit and active transportation networks, which in turn leads to a reduction of VMT.

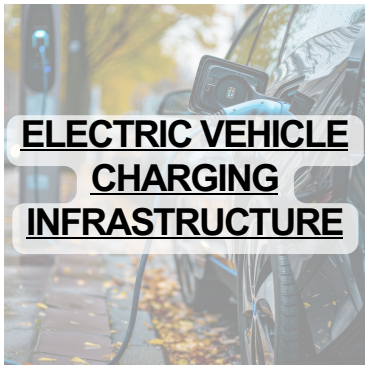
HUD's **Community Development Block Grant (CDBG) Program** supports community development activities to build stronger and more resilient communities. To support community development, activities are identified through an ongoing process. Activities may address needs such as infrastructure, economic development projects, public facilities installation, community centers, housing rehabilitation, public services, clearance/acquisition, microenterprise assistance, code enforcement, homeowner assistance, etc.

FTA's **Areas of Persistent Poverty (AoPP) Program** supports increased transit access for environmental justice (EJ) populations, equity-focused community outreach and public engagement of underserved communities and adoption of equity-focused policies, reducing greenhouse gas emissions, and addressing the effects of climate change.

COMPLEMENTARY STRATEGIES

Zoning codes can influence the design and layout of neighborhoods, including the provision of sidewalks, bike lanes, and pedestrian-friendly infrastructure. By incorporating mixed land uses, reducing distances between destinations, and prioritizing bikeability and walkability, zoning can encourage and support active transportation options such as walking and biking. Additionally, zoning reforms may be needed to enable facilities for bike-sharing and micromobility last mile deliveries.

Zoning codes are a key tool to implement transportation plans by determining land use patterns, densities, and the design of streets and infrastructure. When transportation planning and zoning are coordinated, zoning codes can be aligned with transportation goals to also promote TOD, pedestrian-friendly streetscapes, and mixed-use developments that reduce dependence on personal vehicles and encourage alternative modes of transportation.



Zoning codes can include provisions that require or incentivize the installation of electric vehicle charging stations in new developments, parking facilities, and public spaces. Zoning can also dictate the placement and design of electric vehicle charging infrastructure, and can streamline the permitting process for installing the infrastructure.

Zoning codes typically designate how much parking must be provided for different types of developments, such as residential, commercial, or industrial, as well as which areas may be car-free zones. Coordinating parking reform with zoning reform can improve the efficiency of land designated for parking and encourage ease of access to walking, biking, and public transit.

By shaping land use patterns, densities, and development patterns, zoning can either facilitate or hinder the expansion of public transit infrastructure. Zoning codes that promote mixed-use developments, higher densities, and TOD can create supportive environments for public transit expansion.

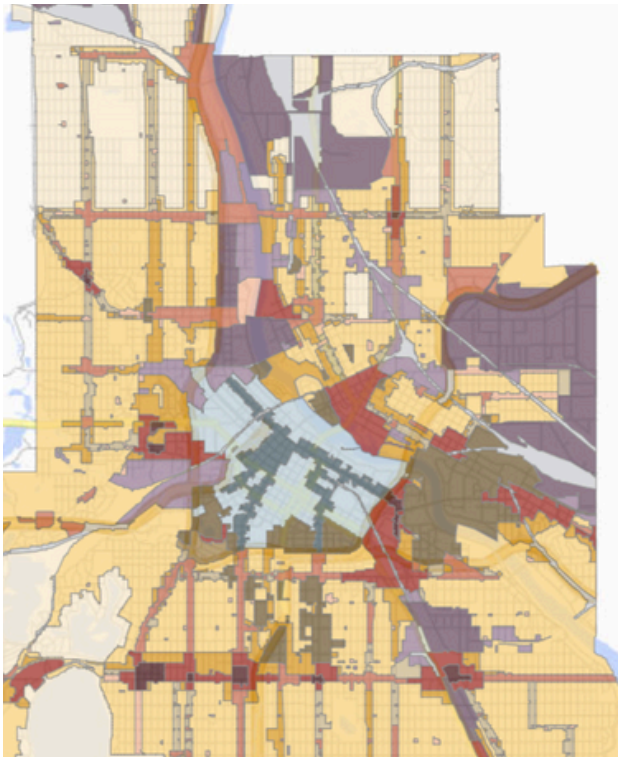
Zoning codes may need to be adjusted to encourage or accommodate TOD principles, such as increased density around transit hubs, mixed land uses, and pedestrian-friendly design. Zoning reform can facilitate the development of TOD projects by allowing for higher densities, reduced parking requirements, and streamlined approval processes, ultimately promoting sustainable and transit-friendly communities.

View All Strategies

CASE STUDIES

BUFFALO, NY UNIFIED DEVELOPMENT ORDINANCE "GREEN CODE"

Buffalo, NY became the first major U.S. city to abolish parking requirements in 2017 when it formally adopted its Unified Development Ordinance (UDO) "Green Code" zoning ordinance, which included the elimination of off-street parking minimums. The elimination of off-street parking minimums helps to promote citywide development, density, and the use of alternative transportation modes.



Updated Minneapolis, MN primary zoning district map (Source: Minneapolis 2040).

MINNEAPOLIS, MN 2040 COMPREHENSIVE PLAN

As required by state law, Minneapolis updated its zoning rules to match the development guidelines that the City Council approved in the Minneapolis 2040 comprehensive plan. Since 2020, the City has worked to meet this requirement by adopting inclusionary zoning, eliminating areas exclusively zoned for single-family, adopting new built form districts and regulations, and eliminating minimum parking requirements. The Land Use Rezoning Study, adopted in 2023, is the next major update to zoning regulations that creates consistency between the zoning code and the comprehensive plan.

PORTLAND, OR RESIDENTIAL INFILL PROJECT

Portland, OR became the largest modern U.S. city to end so-called "single-family zoning" in 2021 with its "Residential Infill Project" (RIP) and associated zoning reforms. The zoning reforms allow new forms of housing on residential parcels previously zoned for a single-family detached house. The new rules also permit new types of housing, and set new, more flexible rules for how the homes can be configured and how large they can be. The overall purpose of the RIP is to provide more density, allowing more housing without increasing Portland's existing footprint.

WASHINGTON STATE, MIDDLE HOUSING

The Washington State Legislature put into effect House Bill 1110, requiring several cities in Washington to include a range of housing types, known as middle housing, in areas previously zoned for detached homes. Middle housing refers to buildings that are compatible with the scale of detached single family housing, in terms of bulk and form, such as duplexes and triplexes, townhouses, and courtyard apartments In Seattle, multi-unit housing types are required in Neighborhood Residential and Residential Small Lot zones by a deadline of June 30, 2025, with some flexibility for addressing issues such as displacement risk and development standards that may create further barriers.

IMPLEMENTING ZONING REFORMS: **WHAT TO READ NEXT**

Implementing zoning projects involves several steps:

1. **Coordinated Transportation Planning**: One of the first steps before reforming zoning codes to reduce greenhouse gas emissions is to perform coordinated transportation planning. Working with partners and stakeholders, develop a comprehensive plan that outlines specific goals and strategies for reducing emissions, including through zoning.
2. **Zoning audit**: Conduct a thorough assessment of current zoning codes and regulations to identify areas for improvement for reducing greenhouse gas emissions.
3. **Stakeholder engagement**: Engage with various stakeholders including local governments, community members, businesses, and environmental organizations to gather input, build support, and ensure that the zoning projects align with community needs and priorities.
4. **Code development**: Draft zoning codes and other land use regulations that incorporate measures to reduce greenhouse gas emissions, such as promoting transit-oriented development.
5. **Public review and approval**: Present the proposed zoning changes to the public for review and feedback. Make adjustments based on public input and seek approval from relevant governing bodies or planning commissions.
6. **Implementation and enforcement**: Once approved, implement the zoning changes by updating official zoning maps and codes. Establish mechanisms for enforcement to ensure compliance with the new regulations, such as permit requirements and inspections.
7. **Monitoring and evaluation**: Continuously monitor the effectiveness of the zoning updates in reducing greenhouse gas emissions. Evaluate progress towards goals and make adjustments to the codes and regulations as needed to improve outcomes.
8. **Education and outreach**: Provide educational resources and outreach efforts to inform the public and stakeholders about the benefits of the zoning projects and how they can contribute to reducing greenhouse gas emissions in their communities.

See the Resources section below for sources that can provide more information on each of these steps.

RESOURCES

GENERAL RESOURCES

APA Equity in Zoning Policy Guide: The zoning policy guide provides zoning tools to position planners to lead the way on zoning for equity at the local, state, and federal level.

Congress for the New Urbanism's Enabling Better Places: Users' Guide to Zoning Code Reform: This guide serves as a resource for Michigan's local governments to implement zoning code changes.

TOOLKITS AND MODELLING APPROACHES

National level

Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model: The model provides life-cycle emissions assessment for different vehicle technologies and futures.

EPA Motor Vehicle Emission Simulator (MOVES): The MOVES model provides vehicle emission rates and mobile-source inventories.

Transportation Pooled Fund VisionEval: The project and associated tools (i.e., Energy Emissions Reduction and Policy Analysis Tool; EERPAT) are designed to evaluate many alternative futures and policies to help state and metropolitan area governments address pressing issues, despite uncertainty.

FTA Transit Greenhouse Gas Emissions Estimator: The estimator is a spreadsheet-based tool that allows users to estimate the partial lifecycle GHG emissions generated from the construction, operation, and maintenance phases of a project across select transit modes. Users input general information about a project, and the Estimator calculates annual GHG emissions generated in each phase.

Infrastructure Carbon Estimator (ICE): ICE is a spreadsheet tool that estimates the lifecycle energy and GHG emissions from the construction and maintenance of transportation facilities. ICE is intended to inform planning and other pre-engineering analysis such as those conducted during the NEPA process.

Mobility Energy Productivity Tool (MEP): This tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

The Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

DOE Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics, for insight on the interconnected impacts between transportation and land use decisions.

DOE and National Renewal Energy Laboratory (NREL) Mobility Energy Productivity (MEP): This metric is used to measure the existing and potential impact of changes in mobility options across transportation modes at the community or regional level. The MEP metric takes into account travel time, energy, and affordability.

DOE's Lawrence Berkely National Laboratory (LBNL) developed the Individual Experienced Utility-Based Synthesis (INEXUS): INEXUS is a suite of accessibility metrics that measure agent-trip level accessibility. These metrics can be used to identify and measure individual travelers who benefit from improved mobility under different simulation scenarios. Tools such as these can be used to design improved operational efficiency in existing and future transportation systems.

State level

APA Michigan Chapter Zoning Reform Toolkit: This toolkit aims to provide urban leaders with tools needed for updating and modernizing zoning and development review regulations to develop more housing types. It also includes case studies on the application of the strategies recommended. This toolkit explains elements of the affordable housing crisis and how zoning reform can act as an intervention. It also provides 15 zoning tools that can be used to address housing supply and affordability.

Massachusetts Housing Toolbox: This toolbox provides strategies and best practices, including zoning and land use tools, for the creation and preservation of affordable housing, with guides, tools and resources for local boards &

committees, planners, municipal staff, developers, and volunteers.

California Quantifying the Effect of Local Government Actions on Vehicle Miles Traveled (VMT): This research resulted in a Vehicle Miles Traveled (VMT) Impact spreadsheet tool, which lets users easily see impacts for any census tract, city, or region in California.

California Emissions Estimator Model (CalEEMod): CalEEMOD is a statewide land use emissions computer model designed to provide a uniform platform for government agencies, land use planners, and environmental professionals to quantify potential criteria pollutant and greenhouse gas (GHG) emissions associated with both construction and operations from a variety of land use projects.

WORKING WITH COMMUNITIES

U.S. Department of Energy's Clean Cities Coalition Network: This network supports communities in achieving cleaner air and reducing dependence on fossil fuels by promoting alternative transportation options.

EPA's Smart Growth: This website provides resources and technical assistance to help communities integrate active transportation into their development plans, promoting compact, walkable neighborhoods.

American Planning Association (APA) Working to Address the Nation's Housing Crisis: The APA provides resources on planning-led zoning reform to address housing supply issues and explore ways planners can work with states to enable reform.

Smart Growth America: Smart Growth America empowers communities through technical assistance, advocacy and thought leadership to create livable places, healthy people, and shared prosperity. Smart Growth America also provides a variety of resources on their website to support community planning efforts and zoning reform.

Center for Neighborhood Technology: The Center for Neighborhood Technology delivers innovative analysis and solutions that support community-based organizations and local governments to create neighborhoods that are equitable, sustainable, and resilient. The Center for Neighborhood Technology provides tools and publications that support planning and zoning reform initiatives on their website.

RURAL SPECIFIC

FTA National Rural Transit Assistance Program (RTAP): This FTA program provides technical resources, toolkits, training, webinars, a resource library, news updates, and information on Tribal transit and State RTAP programs.

AARP Livable Communities Transportation and Mobility: This website includes resources such as policy briefs and a rural transportation toolkit for rural communities on the topics of livability, funding opportunities, health care, and transportation options available in rural areas.

Community Transportation Association for America Transit Planning 4 All: This program, in partnership with several organizations, supports older adults and people with disabilities in getting involved in coordinated transportation system development. The members are involved in surveys, research activities, grants, and creating a knowledge sharing network.

Some rural planning and zoning tools that can help preserve rural character while reducing transportation emissions, adapted from EPA's Essential Smart Growth Fixes for Rural Planning, Zoning, and Development Codes, include:

- **Determine Areas for Growth and for Preservation:** After engaging a community-driven process to plan for which areas shall be targeted for growth and which for preservation, communities may adopt zoning amendments or other development standards and procedures that establish requirements and incentives for focusing growth in designated areas while prohibiting or disincentivizing it in others.
- **Incorporate Fiscal Impact Analysis in Development Reviews:** Rural communities can require fiscal impact analysis within the project development review process to determine how best to allocate their resources and make development decisions that benefit residents.
- **Reform Rural Planned Unit Developments (PUDs):** To provide more control regarding where and how larger scale development may be permitted, rural communities can adopt zoning and subdivision provisions that allow or incentivize new village-scaled development within designated areas where the community has decided it makes sense to grow.

- **Use Wastewater Infrastructure Practices that Meet Development Goals:** Communities may align local zoning and development regulations with wastewater treatment standards to promote development in designated areas that helps reduce transportation emissions while protecting water resources and public health.
- **Right-size rural roads:** Right-sizing rural roads can support reducing transportation emissions by making roads more walkable and bikeable while providing streetscapes that foster mixed-use, compact development where it makes sense such as in town centers.
- **Encourage Appropriate Densities in the Periphery:** Rural communities can develop design regulations that require street connectivity with adjacent neighborhoods, and create land use district transitions to adjacent agricultural or undeveloped areas.
- **Use Cluster Development to Transition from Town to Countryside:** Rural communities can adopt zoning and subdivision provisions that allow cluster development only at the periphery of towns, which helps provide a smooth transition between town-scaled development and open lands (EPA, 2012).

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For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center